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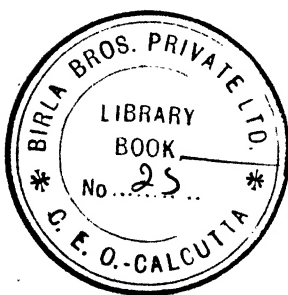
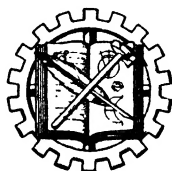
LACQUER AND SYNTHETIC ENAMEL FINISHES

By

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**Composition
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THIS BOOK IS DEDICATED:

Firstly

TO MY MOTHER, WIFE AND DAUGHTERS.
WERE IT NOT FOR THEIR BELIEF AND MORAL SUPPORT, THESE PAGES
WOULD NOT HAVE BEEN WRITTEN.

Secondly

TO THE TECHNICAL MEN OF THE CHEMICAL INDUSTRY,
THROUGH WHOSE DILIGENT EFFORTS THERE RESULTED
THE QUICK DRYING AND DURABLE COATINGS — “LACQUER
AND SYNTHETIC ENAMEL FINISHES.”

PREFACE

In an attempt to allocate the subject of lacquers, their raw materials, manufacture, testing and applications, there has been set forth in this book a résumé of the subject dating from the fore part of the twentieth century to the present time.

No one particular industry has advanced as has the lacquer industry. It has often been stated that if the allied industries of paint and varnish had received the research and attention that has been devoted to lacquer, it is questionable whether lacquer would have reached its prominent stage.

Since the advent of low viscosity cellulose nitrate, butyl alcohol, synthetic solvents and resinous compounds, production has increased to the point where nearly every type of industry employs lacquer in one or more of its processes. A lacquer finish is a sales stimulator and the development of suitable lacquers at a satisfactory market price brought about the partial replacement of varnish and oil enamels. Lacquer is truly the outstanding achievement in the coating industry.

Throughout this publication the subject of discussion is that of cellulose nitrate or acetate basic lacquers and synthetic enamels. A necessary reference has been made to involve certain types of varnishes or enamels which have indicated their compatibility with, or use under or over, a lacquer as an applied schedule. In Part III, Chapter X, Faults and Corrections, reference has necessarily involved paint, varnish and enamels.

As a more concise definition of a lacquer coating, the following is given:

“ In the application of present day lacquers, more than one coat is usually required. These may be applied in rapid succession and, as final stage finishes, may be applied over previous and thoroughly dried coatings. Such lacquer coatings are composed of cellulose nitrate or acetate, solvents, plasticisers, resins and may or may not contain pigment matter. This type of a coating dries by evaporation of the volatile liquids present. As succeeding coatings, if applied in their logical application, are permitted to dry, the volatile or liquid content of the second coating (as a thoroughly wet film) maintains a contact between the two coatings. As setting of the second coat proceeds, the solid gel structure in the two coatings competes for the rapid loss of the liquid content in both coatings. The gel structure of the coating, or one previously applied, is larger in amount and more highly developed than in the coating just applied, or in this instance, the second coat. For this reason, the second coat has the advantage, since it is partly dried in the sense of applied coatings, and is said to be of a porous nature; hence the second application is drawn into the structure of the first coat. As the second coat dries, the absorptive power of the mass increases and, due to the rapidly increased deposit, a greater amount of liquid (as wet lacquer) may be attracted to and held by the surface. As the absorptive power attracts the wet lacquer and draws it through the film (evaporation of the liquid is a quick process), the liquid phase is changed to a semi-gel structure before becoming amalgamated with the deposit of the first application, so that an equalized distribution at this stage is not possible. For this reason, the ability to expand and contract is retarded, since the density and permeability has been affected.”

Synthetic enamels are produced from a varnish base by the addition of opaque pigment matter which is dispersed in the vehicle. The clear varnish base involving glycerine, phthalic anhydride, fatty acids of vegetable compounds and volatile liquids is prepared in much the same manner as the conventional gum and oil (oleo-resinous varnish) combination, in that it is cooked in a kettle over an open fire. In volume production by large suppliers of synthetic resins the procedure involves steam-jacketed kettles, stills, etc. Clear synthetic resinous compounds have many modifications. In addition to the type mentioned above, they may be prepared from phenol com-

pounds, maleic anhydride, etc., and may be modified by the addition of oil or rosin.

Unlike lacquer, synthetic enamels do not dry completely by the evaporation of their volatile constituents, but require heat treatments varying from 175°F to 350°F. Solutions of metal salts are customarily added to insure a thorough hard film.

Synthetic enamels are most frequently used as a one coat finish, although they sometimes involve double applications. In this regard, a mist coat application is applied and air dried or heat treated at about 200°F for 15 minutes or so and a full wet application applied and baked at 225°F to 350°F for periods of 30 minutes to 3 hours. The hardening action which takes place, due to the presence of heat, is one involving oxidation and polymerization.

Thanks and appreciation are accorded The Glidden Company for their permission to use certain definitions of paint and varnish terms, of which they are the copyright owners, and to E. I. du Pont de Nemours and Company for permission to use illustrations of certain photographs of testing devices.

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CONTENTS

PREFACE	v
CONTENTS	ix

PART I

CHAPTER

I GENEALOGY	1
II NITROCELLULOSE — CELLULOSE ACETATE	10
FILM SCRAP — CELLULOSE DERIVATIVES	
III SOLVENTS — NON SOLVENTS	24
IV PLASTICISERS	46
V RESINS AND SYNTHETIC COMPOUNDS	55
VI PIGMENTS	85

PART II

VII PLANT AND EQUIPMENT	113
VIII REQUIREMENTS — TYPES — FORMULATION	155

PART III

IX LABORATORY AND FIELD TESTS	205
X FAULTS AND CORRECTIONS	288

PART IV

XI METHODS OF APPLICATION	321
XII FURNITURE FINISHING	354
XIII MOTOR CAR FINISHING	385

PART V

XIV GLOSSARY OF PAINT, VARNISH, LACQUER AND ALLIED TERMS . .	401
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PART I

CHAPTER I

GENEALOGY

It is fitting to record that the use of coating materials, both for protective and decorative purposes, dates back so far in history that its exact origin is uncertain. Biblical quotations in the first book of the Bible (Genesis 6-14), unearthed records and scientific examination of Egyptian excavations, and embalmings and coatings on mummy cases have identified the use of a bitumen composition. In all probability the coating materials used on mummies was asphaltum dissolved in a volatile oil. These mummies and cases were in a very remarkable state of preservation after their thousands of years of earth captivity. Protective and decorative coating materials had been used thousands of years before the dawn of Christianity and have served mankind throughout the ages as an incidental to world development.

While no direct mention is made of "lacquer" in association with early protective coatings, it is generally assumed that the term originated in China. It is here that the lacquer tree flourishes and quite frequently it is found in Japan and the East Indian islands.

The oldest coating known in history is affiliated with China and the lacquer tree; however, protective and decorative coatings which may emanate from the lacquer tree are of a different structure than the modern version of cellulose nitrate lacquers. The older type of coatings aforementioned are closely allied with varnishes as they are known today, and most likely resulted in melting gum-resins with oils over a fire, and are usually referred to as "Chinese Lacquer."

The present day varnish industry is in like manner closely associated with the name China; it is from here that China wood oil is obtained. The lacquer industry in oriental countries is carried on in much the same manner today as in centuries past and it is said that formulae for lacquer manufacture are handed down from generation to generation. At the same time we find modern China and Japan, who import American manufactured cellulose nitrate lacquers, introducing clay and rice paste and using it in their finishes in much the same manner as introduced in the older coatings for thousands of years.

“Lacquer” as a name has been definitely established. It is a misnomer, however, to identify it with the product as we know it today. It was known many years before the term “varnish.” Investigation of the name “lacquer” has disclosed the following (1):

LAC — Akin to Sanscrit; laksha or raksha (to dye), c.f., lake — litmus.

LAKE — From the same source as lac — a purplish red pigment prepared from lac or cochineal by precipitation of the coloring matter with a metallic compound.

LAKE — A landlocked body of water — a translucent sheet.

LITMUS — Lac plus moes (a thick preparation of fruit pap, probably akin to meat (English).

VARNISH — Probably from the Greek ΒΕΡΕΒΙΚΗΝ — a town in Cyrenaica from whence came a kind of resin, probably sandarac.

Bernice, a Greek goddess — Verinice — vernice — varnish.

CHINESE LACQUER — Sap of the tree rhus vernicifera — not to be confused with the deposits of the insect coccus-lacca from whence comes the burma lac.

4000 B.C. — Ming Dynasty — painting on vellum (character paper).

1125–255 B.C. — Chou Dynasty — decoration of harness, carriages, bows and arrows.

206 B.C.–25 A.D. — Haii Dynasty — pot covers.

960–1279 A.D. — Sung Dynasty — gold and silver added.

1280–1367 A.D. — Ming Dynasty — real development, early stages.

1662–1723 A.D. — Manchu Dynasty — shows greater perfection.

1736–1796 A.D. — Manchu Dynasty — color hard, stereotyped formalism.

1896 A.D. — Imperial factories burned — decadence.

The first factory as a business enterprise was established in England in the late eighteenth century. Varnishes and such coating materials had been made in a somewhat secretive manner; their structures little known, etc., until recent years. Today we find innumerable man-

manufacturers of both varnish and lacquer, whereas at the outset of the present century such lacquer manufacturers could be recorded on the fingers of the hand.

Lacquers as they are generally known today comprise cellulose, resins, solvents and plasticisers and may or may not contain pigment or dye matter. Such lacquers dry by the evaporation of volatile solvents to comparative thin films of lustrous nature.

The genealogy of the present day lacquer would not be complete without the mention of such scientists as: E. C. Worden, Alexander Parks, John H. Stevens, Walter D. Fields, and Richard Hale. These gentlemen, in their research, cover the basic fundamental ingredients of present day lacquers. Such work is recorded as having been enacted in the latter part of the nineteenth century.

Ether and alcohol as solvents, in combination with nitrated cellulose, was the first known lacquer used at that time. Such a product was termed "collodion." The term "pyroxylin" was likewise referred to, and with the advent of material developments supplanted the term "collodion." This collodion of first development presented a non-flexible and non-adhering film on the work. It remained for John H. Stevens, Walter B. Fields and Richard Hale in 1882 to introduce newer solvents and gum-resins into this collodion mixture, which overcame the deficiencies of this coating. As recorded in Brown and Crawford's book (2), considerable work had been under way on both cellulose acetate solutions and cellulose plastics at this time.

Collodion or pyroxylin solutions were first used (1882) in the protective coating field by dip application to brass and such metallic objects as found commercial use indoors. Other types of coating materials in this same category, termed gum lacquers, were used at this time. These gum lacquers relied on film foundation through cold-cut fossil gum-solution in the then known and available solvents. Fusel oil was most frequently used as a gum-solvent in conjunction with benzene and alcohol. Such solutions are still used today and are termed "water dip lacquers." Through the advent of the newer developments, a third type of quick drying solution was presented in a combination of gum and collodion, which found greater favor in the industry and was quite readily accepted. This combination produced greater adhesiveness and flexibility of film. Bronze powder

additions to clear lacquer (collodion) had been the only means to attain an opaque coating until the advent of the accidental discovery of adding lamp black. The addition of lamp black to pyroxylin type material laid the foundation for colored lacquers.

The advent of using cellulose nitrate and acetone in the manufacture of smokeless powder during the World War animated such phenomenal strides as may be directly attributed to the present day widespread use of nitrocellulose lacquers. In this respect, credit is directed to E. I. du Pont de Nemours and Company for their activities. Prior to the period, both before and immediately following the World War, the nitrocellulose industry was generally grouped into three divisions:

Group 1 — Leather Dope Industry.

Group 2 — Bronzing Liquid, mantle dip and collodion.

Group 3 — Lacquers, enamels and cements.

Of this classification, Group 3, having the wider range of usefulness, showed the greatest increase during the period (1915 to 1920) and at that time it was predicted that this group presented the greatest development future.

Collodion, or pyroxylin lacquer, as it was generally known at that period, immediately following the World War, was based on nitrated cellulose. This cellulose was of relatively high nitration and resultant viscosity in solution. Solutions formed from it presented a marked degree of false body as compared with the low viscosity nitrocellulose of today. The suppliers of materials applicable to the three groups mentioned above had, of course, entered into the manufacture of chemicals, smokeless powder, etc., for war activities. Following this period, with innumerable supplies of smokeless powder available, lacquer manufacturers converted this smokeless powder into solutions applicable to Group 1, which presented a great outlet at that time. The advent of low viscosity nitrocellulose was therefore retarded somewhat and it remained for the Hercules Powder Company to develop this remarkable raw material, later to improve it and present a wider range of usefulness. Prior to the above advent and reverting back to that period of war activity, advancement in the

nitrocellulose lacquer field had been further retarded due to Bolshevism in Russia and prohibition in this country. This has reference to fusel oil, a liquid product which is a form of distilled spirits. Fusel oil or, as it is more commonly termed, amyl alcohol (which in turn is essential to produce amyl acetate), was a necessary factor to the progress of lacquer at its inception, as it was an essential high boiling cotton or nitrocellulose solvent.

Acetate of lime was the chief source of acetone in the manufacture of smokeless powder for war activities. This product was produced chiefly in America and Austria and, with increased demands, well directed attempts were started to produce acetone both in the United States and Canada. Several processes, among them the bacteriological, were investigated and one was finally adopted under English patent accredited to Weizmann in 1915. When the United States entered the War a joint purchase with Canada of a distillery at Terre Haute, Indiana, was made to conduct the acetone fermentation process from corn on the Weizmann patent. With all efforts directed toward the production of acetone, butyl alcohol, which resulted as a by-product, was considered useless. Only meager attempts were made to convert it into methyl ethyl ketone as a substitute for the acetone. After the cessation of war activities it remained for the chemist, in an effort to salvage enormous amounts of this so termed useless butyl alcohol, to find that this alcohol and its ester, butyl acetate, could be satisfactorily substituted for fusel oil and amyl acetate. To the Commercial Solvents Corporation credit is given for these efforts. This development coming simultaneously with the development and perfection of low viscosity nitrocellulose, the lacquer industry took on new life and today represents an industry of enormous proportions with an outlet of millions of gallons each year.

Following the development of low viscosity nitrocellulose and butyl alcohol, new life was injected into the industry. Increasing demands on the part of automobile manufacturers for fast production permitted the introduction of this new type of quick drying finish. The motor car industry has greatly benefited, for to finish an automobile under the old method involved hand applications, slow drying and baking which required many hours per job. Today, through the use of lacquer, jobs involving 200 to 300 hours have been cut to from

6 to 12 hours and less. The resultant finish looks better, is better, lasts longer and meets with a greater degree of favor.

It is fitting at this time to record that alcohol has played an important part in the lacquer industry. Next to water, alcohol is the most generally used solvent. It is the backbone of the organo-chemical industry and plays quite as important a part in peace time as in war. Alcohol holds great possibilities as fuel in place of gasoline and is today undergoing serious investigation.

It has only been in recent years that well-directed efforts have resulted in the development of synthetically manufactured solvents and non-solvents. To the Carbide and Carbon Chemical Company credit is directed for their efforts in this field. Synthetic methanol, a product of both America and Germany, tends to play an important part in lacquer activities and may have a bearing on alcohols produced from grain and molasses.

Active efforts on the part of pigment and plasticiser manufacturers have likewise resulted in the development of lacquers as the using public know them today — distinctly American products. Among the outstanding plasticiser developments, the author accredits the Celluloid Corporation for their efforts in producing tricresyl phosphate. The Celluloid Corporation was active in the furtherance of nitrocellulose plastics at the time when Messrs. Hyatt, Stevens, Field, and Hale were conducting the development of newer solvents which today is considered a foundation of this industry.

Advanced methods of testing lacquer finishing materials to insure their ability to withstand weather elements, resistance to abrasion, fading, chalking, etc., have helped to produce the durable quick drying features of the lacquer finish of today. Dr. H. A. Gardner of the Institute of Paint and Varnish Research has been very active in this field and has produced remarkable results in these developments and investigations.

The advancement of lacquer has been phenomenal, so much so that varnish was being replaced and investigation of synthetic resinous compounds were then undertaken. The early version of "synthetic resins" which produced four hour enamels soon retarded such developments as brushing lacquers. The lacquer manufacturers, realizing the possibilities of producing a varnish type coating in the dry-

ing cycle of a true nitrocellulose lacquer, investigated these quick drying enamels and, through research, adopted the use of synthetic resins as a necessary constituent of their product. Such additions (synthetic resins) overcame deficiencies in some of the older type of finishes. To a large extent the greater portion of nitrocellulose lacquers today contains increasing amounts of this resinous compound. The possibilities in this direction are unlimited, as the many modifications of the basic resinous compounds lend themselves to ready incorporation in nitrocellulose lacquers. To this end, a greater life span is injected in the lacquer itself. Today, we find through the media mentioned above, a great increase in the total solids in lacquers over the lacquers of a few years ago. It is reasonable to assume that an attempt will shortly be made to classify these various types of lacquers which, in some instances, comprise no nitrocellulose as basic film formation, but are constructed of straight synthetic resins.

Enamels may be formulated to produce a film which after heat treatment (baking) is not affected by some of the solvents used in its structure. Such an enamel, based on cellulose nitrate, contains goodly amounts of synthetic resinous compounds; therefore, a filter against the actinic rays of sunlight, which results in more durable outdoor finishes and in like manner has a great tendency to expand and contract.

In the story as depicted here the trend is toward synthetics. Synthetics are not artificial in the sense that they are an imitation of a natural product. The chemical composition may be similar to the natural product, and, being produced by regulated rather than by natural means, it is of comparable quality.

It is fitting that some mention should be accorded synthetic enamels in a publication of this type. The presence of heat is necessary by virtue of which the resinous compound is cured and rendered infusible and insoluble. Exacting work with synthetic enamels requires baking ovens with suitable air purification. The resultant hard yet flexible type of films produced is definitely much better in every respect than enamel films produced up to this time. Of definite advantage is the great degree of resistance to the elements.

Let us not lose track of the fact that lacquer is itself a synthetic. Cellulose nitrate is a base of cellulose, structural means of the plant

world. Therefore, being the basis of present day nitrocellulose lacquer, the use of synthetic solvents and synthetic resinous compounds, lacquer can truly be termed a "synthetic." The question of how synthetic a lacquer is, is given as follows:

"If a chemist had sufficient time, it would be possible for him to make a suitable lacquer for automobile use from the following raw materials:

Cotton Dress

Can of Corn Syrup

Bottle of Vinegar

Piece of Coal

Dried Sap of Trees

Ear of Corn

Bottle of Vodka

Bottle of Crude Oil

Smoky Lamp Chimney

Castor Bean Plant

From the COTTON DRESS he could secure, by proper purification, raw cotton, which, by immersion in a mixture of nitric and sulphuric acids, would result in nitrocellulose. This is the basic hardening and toughening agent of present day lacquers.

The CAN OF CORN SYRUP would be the basis for ethyl alcohol used in large quantities in this type of material, both as a solvent for nitrocellulose (the ester) and for resins.

The BOTTLE OF VINEGAR would produce acetic acid. This in conjunction with fusel oil from the VODKA and alcohol from the corn syrup will produce ethyl and amyl acetates. These are essentially solvents for nitrocellulose.

The PIECE OF COAL, through refining process, would produce benzol, toluol and xylol and from the BOTTLE OF CRUDE OIL, satisfactory fractionations of gasoline. These are active resin solvents and are generally used as extenders of lacquer solvents.

The EAR OF CORN would produce butyl alcohol, a product which, with nitrocellulose developments, is considered the backbone of the present day lacquer industry. Through treatment with acetic acid, the corresponding ester, butyl acetate, is likewise secured.

The DRIED SAP OF TREES would produce the fossil gum-resins used in the lacquer industry.

The soot deposit of a SMOKY LAMP CHIMNEY produces a product similar to lamp black, so widely used in the inception of the lacquer industry.

Through crushing and refining the CASTOR BEAN PLANT, the resulting castor oil may be advantageously used as a plasticiser.

A combination of the aforementioned ingredients will produce a satisfactory lacquer product."

While it is the author's desire to hold rigidly to the subject of lacquer and synthetic enamels, applications, faults and corrections, the statement is made that competition is afforded by chromium and nickel platings, stainless steel and plastics. Articles formed of these materials, it is said, do not require protective coatings. There is the further attempt to incorporate coloring matter directly into a metallic surface, but it is the contention that the necessary "dressy" as well as additional protection may be furthered through lacquer and synthetic enamel protective coatings.

Last, but not least, let us pay due respect to the chemist, for it was through his ceaseless efforts that modern protective coatings came into being.

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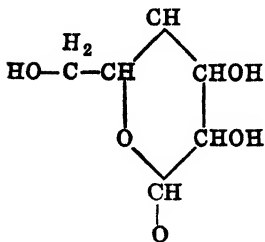
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NITROCELLULOSE
CELLULOSE ACETATE · FILM SCRAP
CELLULOSE DERIVATIVES

Nitrocellulose

Whenever the term “lacquer” is used, we always think of nitrocellulose. This raw material is the backbone of the lacquer industry and is that medium which produces such desirable characteristics as may be found in the present day lacquer product. Nitrocellulose is the general term applied to all combinations of cellulose and nitric acid and was discovered in 1846 by Dr. Schönbein of Switzerland. It is a chemical compound which is a true ester and should rightly be referred to as cellulose nitrate.

Basic structure of cellulose
Glucosidic unit of cellulose



Units of this type are strung together in lengths up to 3000 to 3500. Cellulose may be considered as a polyhydric alcohol amenable to the usual reactions of the aliphatic alcohol groups, but limited by the complexity of the molecule and the mechanical difficulties of attacking the fibres (cotton and wood) which are its source.

Cellulose nitrate is usually defined by its nitrogen content and viscosity, plastics 10.5 to 11.5%, lacquer around 12.0% and explosives nitrocotton nearer 13.0% nitrogen content.

The manufacture of nitrocellulose from cellulose is purely a chemical process. Purified nitrocellulose does not differ in appearance from

the purified cellulose; there is, however, a vast chemical and physio-chemical difference.

The chemical products of cellulose are classified in two general divisions: COTTON and WOOD.

COTTON (in terms of esters and gels, which form the corresponding nitrates and acetates) is the purest form of cellulose. Viscose and fibre, as associated with the plastic and artificial silk industries, are also derived from cotton.

WOOD (in terms of decomposition products, chemical and mechanical pulps) forms the second division of cellulose. The decomposition products of wood, through hydrolysis, produce acetic acid and alcohol; by distillation, acetone, tar and charcoal, and, in terms of both chemical and mechanical pulps, wood is allied with paper in all forms.

Serious investigation and concentrated research was directed toward nitrocellulose during the period of the World War activities. Prior to this period, or at the time when amyl acetate was introduced, the resultant lacquers were of a relatively high viscosity type. The type of lacquers resulting through the use of this nitrocellulose necessitated very great reductions for spray application. Comparatively thin films were deposited on the work and further necessitated several applications which produced brittle films. Following the World War period, low viscosity nitrocellulose was perfected. This development, coupled with solvent development, is considered the basis of the present day lacquer industry. This relatively low viscosity nitrocellulose overcame the deficiencies of the higher viscosity types through greater film deposit on the work. At that period, the low viscosity type included the range of 3 to 8 second viscosity. This was later followed with the $\frac{1}{2}$ second type. With the study and ultimate perfection of these low viscosity products, such deficiencies as color, stability and freedom from granulation were overcome. Through the increase in solid film deposited, newer and more widespread use was found for lacquers. Today the range of available nitrocellulose includes 10–15 centipoise to 1000 second and is further perfected to include not only the R.S. (regularly soluble) type, but the A.S. (alcohol soluble) type as well.

Cotton, the purest form of natural occurring cellulose, is the source of nitrocellulose. The cotton is grown on shrubs or trees and is pro-

duced from seeds. It is an outstanding product of the southern section of the United States. The cotton is plucked in the form of a boll. The boll includes cotton, seeds and such foreign matter.

GINNING — The bolls of cotton are passed through the ginning operation which eliminates the outer or long fibres and leaves the short, fuzzy fibres or linters. These linters are the basis of nitrocellulose as known and used today.

PURIFICATION — The cotton after being removed from the gin is baled and sent to the raw cotton purification plant. Here the bales of linters are thoroughly picked apart and are then introduced into a tank of water with sufficient caustic soda or similar substance to remove the impurities held by the linters. This tank is constructed to withstand varying pressures. The purification process is carried on over varying pressures and for various periods which thoroughly free the cotton of foreign substances, after which the linters are bleached and dried to a moisture content of about 7%.

DRYING — After the cotton is freed of all foreign matter, it is taken from the tank and thoroughly washed to remove all traces of foreign material — then through a squeegee machine to further insure freedom from excess water and is placed on an endless belt and passed over a series of heated steam pipes where it is thoroughly dried. It is then passed through a picking machine where it is broken up into a fluffy and downy mass and is blown into a "hot room" where the last traces of water are removed.

NITRATION — After the linters are dried to a moisture content of about 0.5% they are sent to the nitrating house. The fluffed linters are forked into the nitrators and agitated in a mixture of nitric and sulphuric acids for a definite time and at a closely controlled temperature, and it is during this process that the cellulose is changed into nitrocellulose. In the fundamental unit there are six OH groups which may be replaced all or in part by NO₂ groups. A more complete phase of nitration produces guncotton (13.0% nitrogen). In the particular case of nitrocellulose, nitration is not allowed to proceed to this point, but is stopped when three NO₂ groups are produced.

After nitration has been completed (nitrogen content of between 10.5%–11.5%), the nitrator charge is dropped into tanks (wringers)

which, through centrifugal force, throw the spent acid out of the nitrocellulose. This is accomplished by perforations in a false bottom or basket. Nitrocellulose, which has a high absorbency for liquids, contains considerable acids which must be removed. The nitrocellulose is forked from the sides of the basket, immersed in water and is then floated to the purification area.

ACIDS — The spent acid is saved, analyzed and a mixture of new nitric and sulphuric acid is added to a part of it so that a new nitrating mixed acid is obtained. The excess of spent acid obtained is broken down into sulphuric and nitric acids. The resultant sulphuric acid may be used as an absorbing acid in the catalytic sulphuric acid plant, while the nitric acid may be reconcentrated.

PURIFICATION AFTER NITRATION — This consists of frequent washings to break down and remove the unstable compounds that may be present. This is a very rigid test as even the complete removal of acid does not stabilize nitrocellulose (which is a product of great variation in properties). The basic raw material, cotton, is not pure cellulose (although it is the purest form of cellulose) and always contains oxy- and hydro-celluloses.

The nitrates of these bodies, in addition to the lower nitrates and sulfates of the pure cellulose, are considered unstable. These unstable compounds must be removed thoroughly and completely in order to produce a lacquer which will withstand the disintegration action of the heat and sunlight. As mentioned above, purification treatments are carried on until delicate chemical tests definitely show that the product is of sufficient stability to insure a long life of the product and film made from it. The stability of the product is tested by subjecting the dry material to the action of heat. By various indicator papers, the evolution of the nitrous fumes caused by the decomposition of the nitrocellulose can be detected and measured. This pressure digestion also tends to lower the viscosity of the nitrocellulose to the desired degree.

DEHYDRATION — Following purification and assurance that the greater portion of water has been freed from the nitrocellulose, it is placed into a hydraulic press where excess water is forced out. The block of nitrocellulose thus formed is dehydrated by injection of alcohol to further wash out any last traces of water. This solid block

of nitrocellulose is next taken to a block-breaker where it is torn apart to make it more readily soluble and easier to handle, and is then packed in open head steel barrels ready for the consumer.

Before leaving the group of discussions dealing with the treatment of nitrocellulose, consistent study and prolonged tests indicate that these products are considered stable for the use for which they are intended. This has been proved in production and attempts through experimental work are constantly being conducted to reproduce conditions met with on the basis of laboratory tests. These various testing devices and conditions are detailed in further chapters throughout this publication.

Heavy nitrocellulose solutions should not be heat-treated in order to reduce the viscosity. Such treatments hasten to break down the structure quite rapidly. While the effect of heating has bearing on the viscosity differences, the availability of the range of 10–15 centipoise to 1000 second viscosity types should satisfactorily cover the desired range in solution. This is also true of blending nitrocellulose of varying viscosities, for while an intermediate viscosity will result, the commercial availability of desired types should be employed.

TYPES OF NITROCELLULOSE — The Hercules Powder Company list the following types with comments as noted:

“Nitrocellulose is divided into types governed by its nitrogen content, solubility and viscosity. The standard types of Hercules nitrocellulose which are commonly used in lacquers and plastics are listed. Other grades and required viscosities may be manufactured to meet special requirements.

Viscosity is the usual basis for differentiating between types of nitrocellulose used in the lacquer industry. The standard falling ball viscosity is determined by dissolving nitrocellulose in a mixture of:

(3)

55%	Toluol
25%	No. 1 Denatured ethyl alcohol or 2-B ethyl alcohol
20%	Ethyl acetate
<hr/>	
100%	

All types designated as 5 seconds or higher are determined on a 12.2% dry nitrocellulose solution of the above. The viscosity is

the time in seconds required for a falling ball to drop through ten inches of solution in a one inch diameter glass tube at 25°C. The number of seconds viscosity forms the basis for naming the types of nitrocellulose.

Types designated as $\frac{1}{2}$ second (12.2% solution) are determined on a 20% dry nitrocellulose solution of the above, and the viscosity is measured as 3 to 4 seconds in 20% solution. Types designated as $\frac{1}{4}$ second (12.2% solution) are determined on a 25% dry nitrocellulose solution, and this viscosity ranges from 4 to 5 seconds in 25% solution. These viscosities are also converted into centipoises. Centipoise viscosity is determined on a 12.2% nitrocellulose solution in a capillary viscosimeter.

Hercules types are listed as follows:

RS NITROCELLULOSE — The type known as RS nitrocellulose is the most suitable nitrocellulose for use in mixtures of ester solvents, such as ethyl acetate, butyl acetate, etc., with hydrocarbons such as toluol or petroleum naphtha. RS is the most widely used and the most adaptable type of nitrocellulose. Not only is it soluble in the esters, but it is very soluble in ketones such as acetone, cyclohexanone, methyl ethyl ketone, etc., and also in the various glycol ethers. The standard viscosities of this type are listed with their manufacturing limits and the equivalent centipoises for the lower viscosities. RS nitrocellulose is manufactured in the following viscosities:

<i>Type</i>	<i>Manufacturing Limits</i>	<i>Viscosity in Centipoises of a 12.2% Solution</i>
RS 18-23 CP	18-23 centipoises determined in a 12.2% solution in capillary viscosimeter.	18-23

This is a relatively new and lower viscosity nitrocellulose than has been available previously. Its use in lacquers is constantly increasing because of the high solids content it makes possible. Although the film obtained with this very low viscosity nitrocellulose is less flexible, it is equally as hard as that obtained from higher viscosity nitrocellulose. Regardless of this expected lesser flexibility, this nitrocellulose is highly desirable for use with some of the newly developed resins which are quite soft and need a considerable quantity of nitrocellulose to obtain a sufficiently hard film.

RS $\frac{1}{2}$ second 4 to 5 seconds, determined in a 25% solution
with standard falling ball method. 45-57

RS $\frac{1}{2}$ second is used in automobile, furniture and other lacquers of high solid content and good durability. It is a very popular type for general lacquer use.

RS $\frac{1}{2}$ second 3 to 5 seconds, determined in a 20% solution
with standard falling ball method. 105-140

RS $\frac{1}{2}$ second is the most widely used nitrocellulose in lacquers.

RS 5-6 second 5 to 6 seconds, determined in a 12.12% solu-
tion with standard falling ball method. 1885-2262

RS 5-6 second is similar in all respects to RS $\frac{1}{2}$ second, except for its slightly higher viscosity. It has many uses.

<i>Type</i>	<i>Manufacturing Limits</i>
8- 10 second	8 to 10 seconds
15- 20 second	15 to 20 seconds
30- 40 second	30 to 40 seconds
60- 80 second	60 to 80 seconds
125- 175 second	125 to 175 seconds
250- 400 second	250 to 400 seconds
600-1000 second	600 to 1000 seconds

RS nitrocellulose of 8 to 10 seconds and higher viscosities are used in lacquers, coated fabrics (leather cloth, window shades and miscellaneous fabrics), airplane wing dopes, leather cements, photographic film, collodion solutions, and for many other purposes of a general and special nature.

Intermediate viscosities, other than the above, may be obtained on request.

BRONZING NITROCELLULOSE is manufactured in the following viscosities:

RS $\frac{1}{2}$ second	3 to 4 seconds, determined in a 20% solution with a standard falling ball method.
5-6 second	5 to 6 seconds, determined in a 12.2% solu- tion with standard falling ball method.
40 second	35 to 40 seconds, viscosity determined as above.
70 second	60 to 80 seconds, viscosity determined as above.

This nitrocellulose is specially prepared to hold bronze powders in suspension for a definite period without curdling. It is designed for use in ester solvents as employed with RS nitrocellulose.

SILVER LACQUER NITROCELLULOSE is manufactured in the following viscosities:

20-30 second	20 to 30 seconds, determined on a 12.2% solution with standard falling ball method.
60-80 second	60 to 80 seconds, determined on a 12.2% solution with standard falling ball method.

This nitrocellulose gives a practically water-white solution and is used on highly polished metal surfaces where only a thin, invisible film is needed to prevent tarnishing. It is designed for use in ester solvents as RS nitrocellulose.

AS NITROCELLULOSE — This product, known as AS nitrocellulose, is primarily for use with the same active solvents as RS nitrocellulose, but with alcohol as the diluent instead of hydrocarbons. The difference between AS and RS is illustrated by the following data:

A solution containing:

	<i>by weight</i>
RS $\frac{1}{2}$ second (dry weight)	10.00%
Alcohol of dehydration	4.30
Ethyl acetate	85.70
	<hr/> 100.00%

when diluted with toluol at 25°C until precipitation of the nitrocellulose occurred, gave a dilution ratio (volume of toluol divided by the sum of volumes of ethyl acetate and alcohol) of 3.8, whereas a similar solution of AS $\frac{1}{2}$ second gave a dilution ratio of only 3.2. If alcohol is the diluent, the order of dilution is reversed. It is rather difficult to determine dilution ratios with alcohol, because the end point may be indefinite. However, a similar comparison was made by determining the proportion of active solvent necessary to add to alcohol to obtain a solvent mixture. With RS $\frac{1}{2}$ second, it required 16% ethyl acetate and 84% of alcohol to effect solution; with AS $\frac{1}{2}$ second, it required only 8% of ethyl acetate and 92% of alcohol to effect solution.

AS nitrocellulose is manufactured in the following viscosities:

AS $\frac{1}{4}$ second	3 to 4 seconds, determined on a 20% solution with standard falling ball method.
AS 15-20 second	15 to 20 seconds, determined on a 12.12% solution with standard falling ball method.
AS 30-40 second	30 to 40 seconds, determined on a 12.2% solution with standard falling ball method.

SS NITROCELLULOSE — A type designated as SS nitrocellulose is available and is completely soluble in SD No. 1 denatured alcohol without the addition of any ester, ketone or ether. SS nitrocellulose is offered in the following viscosities:

SS $\frac{1}{4}$ second	4 to 5 seconds, determined on a 25% solution with standard falling ball method.	45-57
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This nitrocellulose is suggested for various uses, some of which are: In odorless lacquers, for certain lacquer sealers, for certain lacquers that are applied mechanically and are dried at slightly elevated temperatures, and for use in conjunction with alcohol soluble resins.

In testing SS nitrocellulose $\frac{1}{4}$ second viscosity with shellac, the solvent being SD No. 1 denatured alcohol, the use of this nitrocellulose materially enhances the hardness and durability of the resultant film.

HERCULOID NITROCELLULOSE — This nitrocellulose is prepared especially for the manufacture of pyroxylin plastics.

Method of shipping: Hercules nitrocellulose is available *wet with water or dehydrated*. Dehydration media are denatured alcohol, isopropyl alcohol or butyl alcohol.

Note: The label on the side or stenciling on the top of barrels shows the type and viscosity range and, besides, will show the actual viscosity. Nitrocellulose $\frac{1}{4}$ second viscosity is so marked on the label, and also the actual viscosity in a 20% solution is shown. For example, in the marking viscosity $x/20$, "x" indicates the actual viscosity from 3 to 4 seconds. Nitrocellulose $\frac{1}{4}$ second shows the actual viscosity in a 25% solution. Thus, in viscosity $x/25$, "x" is the actual viscosity from 4 to 5 seconds."

Cellulose Acetate

While cellulose nitrate has been known since Schönbein's investigations in 1846 and has found a widening field of usefulness in

industry up to the present time, cellulose acetate has found many and increasing applications in technical operations where stability to heat and light are of importance, in spite of the fact that its origin is of more recent date. The first record of an acetylated carbohydrate is found in the memoirs of Schultzenberger in 1862 and the first patent for the manufacture of cellulose acetate was granted to Cross and Bevan in 1894.

Because of its many desirable properties in comparison with cellulose nitrate, the industrial development of cellulose acetate has progressed to the point where today it finds extensive use in the photographic arts, fabrication of molding and insulating compounds, and, to a certain extent, in lacquers. It is particularly well adapted to conditions where stability and permanence, coupled with very much decreased flammability, are of first importance.

Cellulose acetate, in conjunction with proper plasticisers, may be coated from volatile solvents, as a tough, clear, colorless sheet, may be compounded with dyes and pigments to form molding compounds and may be spun from volatile solvents to form a superior grade of synthetic fibre or artificial silk. In a spraying lacquer, it finds widespread use where low flammability is required as, for example, in airplane coverings.

It is not necessary in this connection to be particularly concerned with methods of the manufacture of cellulose acetate, except to say that the usual method involves solution of a cellulosic material such as cotton or wood pulp in a mixture of acetic acid and acetic anhydride. The fully acetylated cellulose contains about 45% acetyl, and in this condition finds little commercial use. A subsequent process of hydrolysis reduces the acetyl content to from 37% to 42%, where solubility in a wide range of solvents and solvent mixtures may be obtained. The cellulose acetate is then removed from its acetic acid solution, washed completely free of acid, and dried.

While heretofore the development of cellulose acetate has been hindered by its high cost, lack of uniformity of properties, and subsequent lack of demand, it may now be said that earnest work on the part of serious investigators in old and well established industries has resulted in a product of remarkable uniformity in a price range heretofore believed impossible. With the outstanding prop-

erties recognized by the trade, greater strides in usefulness may be expected.

Cellulose acetate may be obtained in a wide range of acetyl content, degrees of resistance to moisture and resultant viscosity, and upon these characteristics depend the choice of solvent and solvent mixtures which may be employed. Cellulose acetate of low acetyl content (37%) shows general solubility in a wider range of solvents, and permits of greater dilution with non-solvents. Cellulose acetate of medium acetyl content (38%) has a lesser tolerance for non-solvents but shows a greater resistance to moisture, while cellulose acetate of higher acetyl content (41%) is characterized by solubility in a somewhat decreased number of solvents and by high resistance to moisture.

Cellulose acetate has been limited in its industrial application as a coating material, perhaps largely due to the limited number of plasticisers and resins with which it is compatible. Certain of the alkyd resinous compounds have recently opened up newer uses and, with the consistent study devoted to these newer developments, it is expected that cellulose acetate will take its place as a widely used cellulosic compound.

Film Scrap

The Motion Picture Industry presents the greatest single source of nitrate scrap film. In the filming of a motion picture, thousands of feet of sensitive film are exposed and eventually trimmed down to the required length. From this negative, great numbers of positive copies are made for distribution to the theatres throughout the country. When their usefulness is outlived, these films are disposed of in order to reclaim their silver and nitrocellulose content. Because of the potential value of scrap film, it is natural that considerable effort has been made to find good use for it, with the result that today reworked film scrap finds extensive use in the manufacture of artificial leather, adhesives, dope solutions for many purposes, and various types of lacquers.

The suitability of film scrap for lacquer and other purposes depends largely on the thoroughness of removal of the sensitive silver emulsion. When carried on under proper conditions, there results

a very satisfactory grade of material comparable in its properties with new nitrocellulose.

For the removal of the gelatin solution, some reclaimers rewind the film on large wooden racks so as to expose the film on both sides and immerse it in hot water in large wooden tanks. Occasionally, chemicals are added to hasten the removal of the emulsion layer. After the gelatin is well softened, it may be removed from the film by further agitation and washing in special machines, and, in the case of film being reclaimed in the strip, mechanical aid from brushes or the like will assist in complete removal of the gelatin layer. Thorough washing follows, after which the film scrap is dried at a low temperature. For use in lacquers, particularly, thorough drying is essential, since the presence of water is usually detrimental in lacquer formulae. The silver salts in the dilute wash waters are concentrated by settling or filtration, and the dried silver mud sent to the refinery for subsequent recovery of the silver bullion.

For making lacquers it is customary to dissolve the washed and dried film scrap in a solution containing a minimum of active solvent — a lean mixture, so called. Film scrap enters the industry as solutions for use in clear and colored lacquers. Attempts to reduce the viscosity of film scrap by chemical means or by heat treatment have not resulted in a satisfactory product. Where nitrocellulose of medium or high viscosity is required, as in the manufacture of artificial leather dope, wire lacquers, adhesives, etc., this reclaimed film scrap solution finds widespread and satisfactory usage.

Due to the hazard of dry nitrate film, care should be taken to comply with any local ordinances. The storage of a nitrocellulose solution in drums or barrels, however, offers less difficulty and detailed instructions for storage should be obtained from sources such as the National Fire Protective Association and the National Board of Fire Underwriters, who have prepared publications covering this field.

The nitrocellulose usually met with in motion picture film is of a relatively high viscosity and, for this reason, is not suitable for the manufacture of the so-called safety film, which is made on a cellulose acetate base. This safety film is reclaimed in a similar manner for a different variety of products for which, by reason of its

non-flammability and other desirable properties, it is particularly well adapted.

Cellulose Compounds

ETHYL CELLULOSE: The ethyl ethers of cellulose are of recent development and it has been in the past few years that their appearance in the lacquer industry has been noted. Ethyl cellulose is a cellulose ether made by the reaction of ethyl chloride upon alkali cellulose. Being ethers and not esters, their ultimate deterioration does not tend to liberate acid to further accelerate the decomposition of the cellulose.

Ethyl cellulose films are characterized by flexibility, acid and alkali resistance, elasticity, fireproofing qualities and solubility in cheaper and non-flammable solvents.

The plasticisers of the cellulose nitrate range may be used in quantities up to 30% of the weight of the ethyl cellulose. The use of plasticisers is not necessary to achieve flexibility. Cellulose nitrate is in like manner compatible with these ethers, while cellulose acetate is not.

Fossil gum-resins or synthetic resinous compounds may be incorporated to increase the gloss and adhesion, but where strength is requisite, should only be incorporated to the extent of 40% by weight of the ethyl cellulose. The addition of resins tend to retard the weathering resistance.

Solubility: The coal tar hydrocarbons with the addition of 10% denatured ethyl alcohol, ethylene dichloride, carbon tetrachloride, ketones, alcohols, esters, ethyl glycol and derivatives will cover the general range of available solvents. Petroleum hydrocarbons are non-solvents.

These lacquers are recommended as a coating medium for airplane wing dope because of their non-flammable nature, as a paper coating medium, leather and embossing lacquers and many purposes where flexibility and fire resistance are desired. Of special note is their recommendation as metal coatings.

CELLULOSE ACETOBUTYRATE (HERCOSE "C") — This cellulose ester of low flammability has recently made its commercial appearance. It is a product of the Hercules Powder Company. It is said of

this cellulose derivative that it is particularly useful in non-discoloring lacquers and has a high degree of moisture resistance, with an improved resistance to weak acids and alkalis.

The following properties are noted: *color*, water white; *odor*, none; *solubility* ketones, esters; *uses*, cable lacquers, flexible lacquers and metal lacquers.

CELLULOSE ACETOPROPIONATE (HERCOSE "AP") — This cellulose ester is one of the recent raw materials introduced by the Hercules Powder Company. This material produces flexible films of a hard and transparent nature. It is soluble in a wide range of cheap solvents and has a wide range of miscibility with various resins.

The following properties are noted: *color*, water white; *odor*, none; *discoloration*, practically none; *resistance*, more resistant than cellulose acetate toward acids and alkalis.

TORNESIT (CHLORINATED RUBBER) — A chlorinated rubber compound recently introduced by the Hercules Powder Company. It possesses high resistance to acids and alkalis. This product shows great promise, especially where adhesion factors in an air drying material are concerned. Wider ranges of solvent compatibility, as well as plasticiser and resins, may open a field for this material to include air drying cement coatings, pipe coatings, etc., which have been limited in nitrocellulose lacquers.

REFERENCE

(3) This is the same formula as that listed on page 21, of the Hercules Nitrocellulose Handbook and page A-293, A.S.T.M. standards on preservative coatings for structural materials (paints, varnishes, lacquers and paint materials).

SOLVENTS, NON-SOLVENTS

Solvent is the term applied in the protective coating industry to liquids which dissolve nitrocellulose or resins and are of a volatile nature, therefore evaporate completely from the film. The substance solvated is activated by the solvents and is permitted through such activation to penetrate wood, fibre, paper, etc., as in the instance of lacquer applied as furniture finishes. Solvents are truly raw materials of the coating industry, and as such they are quite necessarily a part of the finish.

In the early development of lacquer, its advancement was retarded because of the unavailability of a greater range of solvents and also because of the instability of available solvents and lack of knowledge of requirements of that time. As further brought out in Chapter I, Part I, the advent of butyl alcohol and its ester, butyl acetate, laid the solvent foundation of the present day lacquer industry.

Solvent portions of a given lacquer are divided into two main divisions: SOLVENTS and DILUENTS or NON-SOLVENTS. The solvent is subdivided into two divisions: (1) true solvents and (2) latent solvents. The diluents or non-solvents are subdivided into two divisions: (1) hydrocarbons and (2) alcohols.

The true solvent range of lacquer volatiles includes the series of esters. An ester is usually a liquid and customarily is secured through the reaction of an alcohol and an acid. The pure alcohols are classified as latent solvents which indicate that they act as latent solvents in the presence of an ester. Butyl alcohol, as an example, will not dis-

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solve nitrocellulose, but with butyl acetate, the alcohol becomes activated and acts as a true solvent.

It is the function of the diluent or non-solvent to lower the cost of the solvent mixture. The aromatic hydrocarbons or coal tar derivatives are commonly used. A second type of diluent frequently used is the petroleum naphtha, which resembles gasoline. These are cheaper in price than the aromatic hydrocarbons, but are used in sparing amounts in lacquers. Diluents are closely allied with the term "resin solvents" and are classified as low and high boilers in the same manner as nitrocellulose solvents. The petroleum hydrocarbons are added in lesser amounts to a given lacquer than the coal tar or aromatic hydrocarbons. This, however, is counterbalanced if a little additional normal butyl alcohol is employed. Diluents also affect the flow, vaporization and surface tension characteristics of the mixture to which they have been added. Coal tar or the petroleum hydrocarbons which are used in sparing amounts in lacquer formulation become the main volatile constituents of synthetic enamels.

Solvents carry responsibility and proportions may not vary as in the instance of varnish and paint, where often as great a spread as 15% additional of a solvent may be acceptable to the performance of the product. Solvents are of three general classifications: low boilers, medium boilers and high boilers. It is the function of the low boiling solvents (below 100°C) to aid in carrying the nitrocellulose in solution and volatility to the lacquer, which will permit its rapid drying features, and to reduce its cost. Ethyl acetate in this class is an ester that is frequently used and has a decided liquefying effect on nitrocellulose. The high boiling solvents (above 150°C) are to provide leveling of the film and aid in preventing "blushing" and orange peel effect. Such solvents as amyl acetate and ethyl lactate fall in this classification. Medium boiling solvents (near 125°C), paramount of butyl acetate, are the "in-betweens" of the two types mentioned above, and prevent too rapid a "set-up" of the lacquer film.

The chemical development of the lacquer industry has presented a great range of organic liquids. These liquids of varying properties and intended uses have necessarily kept the lacquer chemist quite alert in keeping abreast of these modern developments. The subject

of solvents and non-solvents is further discussed under the chapters on Tests and Faults and Corrections.

The desirable properties of nitrocellulose solvents and non-solvents should include:

- (1) Commercial availability.
- (2) Uniformity in chemical and physical properties.
- (3) Must be inexpensive.
- (4) Must have great solvent power.
- (5) Must have a satisfactory evaporation rate.
- (6) Must be miscible with other solvents.
- (7) Must be non-hygroscopic.
- (8) Must have a satisfactory odor.
- (9) Must be non-toxic.
- (10) Must have a satisfactory dilution ratio.

1. *Availability.* With advanced methods of manufacture, research, and lengthy development, new commodities are presented to the lacquer industry in commercial quantities and at moderate prices. The commercial availability of solvents is practically assured, and unlooked for shortage of solvents is not likely to occur. The lacquer chemist, with study devoted to vapor pressure, evaporation rate, etc., is capable, through intermixing, of directly substituting for a given solvent.

2. *Stability.* The uniformity of products should be under very rigid control of the manufacturer at all times if desired results are to be obtained. Satisfactory stability of solvents under conditions governing its use is important. The purity of the solvent has in most cases great influence on the solubility exerted on nitrocellulose and resins. The repression of solubility through the presence of impurities will present an example of the opposite solubility effect. The presence of free acids in lacquers was responsible for the retardment in the earlier advancement of lacquers. Acid tends to decompose the nitrocellulose and, if the lacquer is applied on a metal surface, will liberate rust forming chemicals causing corrosion. Acid also affects pigment if present in such a lacquer by chemically changing its color.

3. *Cost.* Many solvents considered laboratory curiosities a few years ago are now presented on a commercial basis and within a satisfactory price range whereby they are extensively in use today. Gener-

ally speaking, the high evaporation ratio and resultant film retention properties of recently presented solvents will give a using price of satisfactory nature in view of dilution with cheaper solvents and diluents. This dilution does not greatly harm its solvent properties.

4. *Solvency*. Solvent power on nitrocellulose should take place immediately upon immersion, and gel formation should not result. The solvated mass should be entirely of a viscous nature, free of gel structure. Solvent power will vary for the different solvents used. The more powerful solvents have lower viscosities. This is desirable, as through mechanical (spray gun) application, fewer coats of permanent film having true solid deposit on the work may be accomplished. Solvent power is generally expressed in terms of dilution ratio (see dilution ratio, Part 10, under this subject).

5. *Evaporation*. The evaporation rate of solvents is quite an important factor. Under identical conditions all liquids will evaporate at various rates, due to differences in their vapor pressures. Let us not forget that lacquers dry by evaporation of these volatile solvents, therefore the evaporation rate of a liquid from a lacquer film has a decided bearing on the resultant appearance of such films. It should be understood that the rate of evaporation of any solvent or mixture of solvents is greatly altered by the material in which it may be dissolved. The high vapor pressure of low boiling solvents will cause blushing or an orange peel effect on the surface if present in large proportions in a lacquer film. This rapid evaporation "sets-up" the film and does not permit satisfactory leveling. The higher the initial boiling point of a solvent, the slower the rate of evaporation. When a low boiling ester is mixed with a non-solvent or diluent, the nitrocellulose will remain in solution only for that period that the ester is present in the film. Evaporation curves are more carefully considered than the boiling range of a given solvent, and the plotting and use of vapor pressure curves is a more accurate method for the evaluation of a given solvent than study of the boiling point. Too much stress cannot be placed on the importance of the rate of evaporation. Formation of constant evaporating mixtures and molecular complexes exert a marked effect on the vapor pressures of a mixture (volatile thinner). Generally speaking, factors governing speed of evaporation are: (a) temperature, (b) quantity of vapor present in

the surrounding atmosphere, (c) rapidity of renewed atmosphere, and (d) size of drying surface given over to evaporation.

6. *Tolerance.* A satisfactory solvent should be completely miscible with all ingredients which constitute a given lacquer, otherwise the balance of the lacquer structure may be disturbed during the period of drying. The evaporation rate of solvents has bearing on this feature and should include a proper balance of solvent and diluent which are compatible with both the nitrocellulose, resin and/or pigment present.

The tolerance of the solvent with respect to retaining the nitrocellulose in solution even in the presence of such extenders as petroleum hydrocarbons is essential.

7. *Hygroscopicity.* Desirable solvents should be non-hygroscopic as they may absorb moisture and disrupt the film characteristics. When lacquers are applied on a surface, evaporation takes place immediately. This is always accomplished by a decided cooling action. This rapid cooling causes the precipitation of moisture from the atmosphere onto the lacquer film. As the cooling action continues and the moisture forms on the film, the nitrocellulose which is insoluble in water is precipitated in the form of a white cloud. This is termed "blushing" and is usually present on hot humid days. Great care should be given the selection of solvents; those solvents, miscible with water, should be counterbalanced with the high boiling solvents. This happy medium will produce an even rate of evaporation which in turn will result in a level and continuous film. The high boiling solvents will retard the evaporation progress and keep the film slightly mobile until it is dried. The highest boiling solvent in a given film of lacquer should be a true nitrocellulose solvent. In this manner the high boiling solvent should be the last liquid portion to evaporate and will not cause the nitrocellulose to precipitate. Such high boiling solvents often form constant boiling mixtures with water and consequently aid in removing excess water or moisture from drying films by evaporating jointly with the water present. Butyl alcohol is universally regarded as a blush preventative, being an excellent dehydrating agent. The decreases in temperature caused by the evaporation of solvents has been determined by H. Dabisch (4). Seasonal changes of weather necessitate the use of different thinners for summer than for winter. The higher humidity in the summer months

necessitates solvents which do not absorb moisture for the best results.

8. *Odor.* The odor of solvents is quite important, as practically all lacquers are applied indoors. The spray gun medium is invariably used, and forced expulsion of fumes takes place; however, the odor should not affect workers who apply lacquers. Solvents and lacquers cannot be considered entirely odorless, but they may be manufactured to present in spray application, through atomization, an odor considered pleasant and non-objectionable.

9. *Toxicity.* In like manner solvents must be of a non-toxic nature. Benzol and methyl alcohol are considered toxic and legislative rule in various states prohibits their use. The physiological action of solvents exerts a noticeable effect without actual injury.

10. *Dilution Ratio.* The solvent power of various solvents differs in its ability to dissolve nitrocellulose. The determination is carried out through a definite amount of solvent and nitrocellulose, and precipitation is fixed with either a hydrocarbon or a petroleum naphtha.

Dilution ratio is generally defined as the ratio of the weight of diluent (non-solvent) to the weight of solvent at which the mixture just ceases to be a solvent for nitrocellulose, at a different concentration, e.g., 8%. As mentioned, diluents are added to lacquers with the object of cheapening. Petroleum fractionations permit only a limited addition to a given lacquer. This has a marked bearing on the solvent power of nitrocellulose solvents with which it may enter into a given lacquer. Solutions of nitrocellulose will tolerate a given amount of non-solvent or diluent, but when that critical point is reached, further additions will cause precipitation of the nitrocellulose.

Dilution ratio of some important solvents follow: 50 cc. of solvent were used and their dilution with toluol (coal tar hydrocarbon) and lactol spirits (petroleum hydrocarbon) were carried on until precipitation of the nitrocellulose had been executed.

	cc toluol	cc lactol spirits	toluol ratio	lactol spirits ratio
Ethyl acetate	392	100	7.85	2.00
Butyl acetate	310	119	6.20	2.40
Amyl acetate	271	117	5.40	2.34
Butyl propionate	261	104	5.20	2.00
Ethyl lactate	509	91	10.20	1.90
Butyl acetate, secondary	286	110	5.73	2.30
Pentacetate	271	117	5.40	2.34
Cellosolve	444	101	8.88	2.03
Cellosolve acetate	286	88	5.73	1.76
Butyl cellosolve	384	164	6.67	3.30

Plasticisers are considered permanent solvents acting as a retainer in the film after drying. These are discussed under Part I, Chapter IV.

Fermentation principles still play an important part in the production of solvents. The carbohydrates entering into the fermentation process are being converted into synthetic methanol, which permits an outlet for what has been considered a spent product. Synthetic solvents from petroleum gases are now forming the basis for a huge American industry.

Following are some of the solvents and non-solvents employed in lacquer formulation. These are arranged in the order of boiling points:

LOW BOILERS (below 100°C) <i>reduce viscosity, evaporate quickly and produce quick drying features</i>		MEDIUM BOILERS (near 125°C) <i>contribute "flowing properties"</i>		HIGH BOILERS (above 150°C) <i>prevent "blushing" and assist in the final flow</i>	
Ethyl ether	34°C	Butyl alcohol	100°C	Cyclohexanone	150°C
Acetone	57	Dioxan	101	Furfural	150
Methyl acetate	57	Sec. Butyl acetate	102	Hexalin	154
Ethyl acetate	70	Toluol	110	Butyl acetate	155
Ethyl alcohol	78	Butyl propionate	116	Butyl cellosolve	163
Isopropyl alcohol	80	Pentanol	116	Methyl hexalin	165
Ethyl methyl ketone	80	Amyl alcohol	118	Di-isobutyl ketone	168
Isopropyl acetate	84	Methyl cellosolve	118	Hexalin acetate	175
Tertiary amyl alcohol	89	Butyl acetate	120	Furfural alcohol	177
Secondary butyl alcohol	95	Diethyl carbonate	120	Carbitol	180
Ethyl propionate	98	Secondary amyl acetate	120	Ethyl acetyl glycolate	181
		Ethyl butyrate	121	Diethyl oxalate	185
		Pentacetate	126	Octyl acetate	199
		Cellosolve	130	Benzyl alcohol	204
		Diacetone	130	Tetralin	205
		Xylol	132	Benzyl acetate	213
		Ethyl lactate	137	Butyl carbitol	215
		Amyl alcohol	137	Benzyl benzoate	320
		Ethoxy butyrate	138		
		Butyl butyrate	138		
		Cellosolve acetate	145		

ALCOHOL — Alcohol is as important to the manufacture of lacquers as the nitrocellulose, resin and/or pigment it may contain. It is the basic foundation of many solvents and plasticisers entering into this product. Next to water it is the most generally used solvent. It is a basic raw material of the organo-chemical industry as illustrated

by the following uses: Anti-freeze compound, nitrocellulose, solvents, cosmetics, tobacco, food industry, cleaning solutions, ethylene, surgery, warfare, and fuel.

As a basic raw material the lacquer industry owes much to alcohol. The function of these products has been set forth under the introductory heading of this chapter.

Alcohols are not considered true solvents for nitrocellulose because they do not dissolve the nitrocellulose. However, in conjunction with a small amount of an ether or an ester they become solvents themselves. Alcohols, in this respect, are referred to as latent solvents, and the property of solvation is often referred to as a colloidal action. The degree of activation in the presence of various nitrocellulose solvents will likewise vary.

The use of synthetic products and processes are becoming more and more common in alcohol manufacture. Fermentation butyl alcohol not only faces competition from other solvents, but from synthetic butanol made from acetylene. Methanol of synthetic basis is received quite favorably and has greatly supplanted wood alcohol.

The petroleum industry presents strong competition and has had an outstanding development in recent years in the development and perfection of the "cracking process" of gasoline. This produces the gases; ethylene, butylene and amylene, from which the corresponding alcohols have been derived. Butyl alcohol or butanol as it is more commonly termed, still maintains its supremacy in the alcohol field, with respect to lacquer manufacture.

Alcohol is produced by the fermentation of sugar, by the fermentation of starch or is produced synthetically by a number of different methods. Alcohol produced by the fermentation of sugar solution accounts for over 75% of the production in the United States. Blackstrap molasses is principally used. The molasses is made up into a mash by intermixture with water, yeast is added to the mash and fermentation takes place. The resulting "beer" is distilled and the alcohol is separated.

The fermentation of starch to alcohol involves grain (starch) which is cooked, treated and converted to sugar, and of sugar to ethyl alcohol.

Synthetic ethyl alcohol is mostly produced from natural gas sources or obtained from the cracking of petroleum.

DENATURED ALCOHOL — Denatured alcohols enter the lacquer industry in two general forms: completely denatured alcohol, which is ethyl alcohol having been rendered unfit for beverage use by the addition of denaturants as prescribed by the Department of Internal Revenue. Such alcohols may be used by the general public without filing bond or securing permit for use. They are used expressly as a medium for cutting shellac, and as a medium of reduction for shellac cuts.

Specially denatured alcohol is ethyl alcohol treated with prescribed denaturants to permit its use in specialized industries. A permit to use, and a bond must be posted. Used expressly as the denatured alcohol entering into the manufacture of lacquers. Where shellac is dissolved at a lacquer manufacturing plant, this specially denatured alcohol is most frequently used.

ANHYDROUS ALCOHOL — These low boiling and water free alcohols form constant boiling mixtures with any condensed water. They find, therefore, potential outlets as a retarding medium of "blushing." This is only because of their water free nature. Used as a solvent for alcohol soluble (AS) nitrocellulose; dissolving this type quite readily. The addition of ethyl acetate to anhydrous alcohol renders complete solubility of regular soluble (RS) nitrocellulose as well. It is also a solvent for resins.

Physical Properties

<i>Commercial Name</i>	<i>Chemical Name and Formula</i>	<i>Sp. Gr. 20°/20°C</i>	<i>Boiling Point</i>
ETHYL ETHER (Sulphuric ether)	ETHYL ETHER (C ₂ H ₅) ₂ O	0.719	34°C

A very low boiling nitrocellulose solvent, generally used in conjunction with alcohol. It is highly inflammable.

DIMETHYL KETONE	ACETONE	0.792 @15°C	56°C
	$\begin{array}{c} \text{CH}_3 \\ \diagdown \\ \text{C} = \text{O} \\ \diagup \\ \text{CH}_3 \end{array}$		

Acetone is prepared through the process of the destructive distillation of wood, as a by-product of starch fermentation and synthetically from propylene. The production of acetone through the exploitation of the fermentation of corn during the World War period, with the resulting discovery of butanol and butyl acetate, laid the solvent foundation of the lacquer industry today. Acetone is a nitrocellulose and cellulose acetate solvent of great power and is compatible with most resins and oils. Further uses are as a raw material in the manufacture of diacetone, mesityl oxide and as a denaturant in specially denatured alcohol. While it is a powerful solvent and is used quite extensively, it is a low boiler and of hygroscopic nature, and, if used, should be counterbalanced with high boilers. It is highly inflammable.

METHYL ACETATE	METHYL ACETATE	0.932	58°C
	$\text{CH}_3.\text{COO}.\text{CH}_3$		

A nitrocellulose and cellulose acetate solvent. Somewhat superior to acetone for solvent power. It is little used, however, because of its toxicity. Manufactured by the esterification of acetic acid with methanol, using H_2SO_4 as a catalyst.

METHYL ALCOHOL	METHYL ALCOHOL	0.796	64°C
METHANOL 99.8%	(METHANOL)		
(WOOD ALCOHOL)	CH_3OH		

This alcohol is produced during the distillation of hard woods with acetic acid, and was one of the earlier solvents used in conjunction with lacquers. At present it is made synthetically by combining carbon monoxide and hydrogen under pressure by the aid of a catalyst. It is of a slightly toxic nature. Methyl alcohol finds use as a denaturant for specially denatured alcohol and is also used in the manufacture of wood stains and in paint and varnish removers. It is also used in the manufacture of formaldehyde, which enters into the manufacture of synthetic resins. In the presence of acetone, it is a solvent for nitrocellulose, and in conjunction with nitrocellulose manufacturing, methyl alcohol is largely replaced by denatured ethyl alcohol.

ETHYL ACETATE	ETHYL ACETATE	0.884	70-80°C
	$\text{CH}_3.\text{COO}.\text{C}_2\text{H}_5$		

Ethyl acetate is one of the most important nitrocellulose solvents used in the lacquer industry, one of the most frequently used and has occupied a unique position in the industry because it is the cheapest of the low boiling solvents. Having a low boiling range and evaporating point, it will cause "blushing" of a lacquer under adverse weather conditions unless higher boilers are present. This, plus its hygroscopicity, makes it impossible to use alone in lacquer formulation. There are two grades: anhydrous 99–100% ester and commercial grade 85–88% ester. The latter is prepared by esterification of acetic acid with alcohol. It may also be prepared from acetate of lime and alcohol. Because of the residual odor of acetate of lime impurities, the former is considered the better product. Commercial grade is generally used in manufacturing lacquer thinners.

ETHYL ALCOHOL	ETHYL ALCOHOL	0.811	78°C
	C_2H_5OH		

This alcohol is considered important as the basis of the production of ethyl acetate, and is used by the manufacturers of nitrocellulose as the wetting agent (*see* ALCOHOL, this chapter).

ETHYL METHYL KETONE	ETHYL METHYL KETONE	0.805	80°C
	$CH_3COC_2H_5$		

A low boiling nitrocellulose and cellulose acetate solvent prepared from acetone. Synthetic ethyl methyl ketone has met with great favor in the lacquer industry.

ISOPROPYL ALCOHOL	ISOPROPYL ALCOHOL	0.823	80°C
	$CH_3CH.OHCH_3$	@ 15°C	

Made from propylene, a gas produced in the "cracking" of gasoline. It is also obtained from fusel oil. Uses are: denaturant for ethyl alcohol, lacquer diluent, and a resin solvent.

ISOPROPYL ACETATE	ISOPROPYL ACETATE	0.867	84°C
	$CH_3COOC_3H_7$		

Proposed as a substitute for ethyl acetate and, where price is a fac-

tor, as part substitute for butyl acetates. Actual evaporation ratio is between ethyl and butyl acetates. A solvent for nitrocellulose.

AMYL ALCOHOL	DIMETHYL ETHYL CARBINOL TERTIARY AMYL ALCOHOL $C_6H_{11}OH$	0.806	89°C
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The lowest boiling of the commonly known amyl alcohols. It is a solvent for resins. "Cracking" of gasoline produces the secondary alcohols. These products are not carried as far as the normal products, with respect to odor.

SECONDARY BUTYL ALCOHOL METHYL ETHYL CARBINOL	BUTYL ALCOHOL, SECONDARY $CH_3 \begin{array}{l} \diagup \\ \diagdown \end{array} CH.OH$ C_2H_5	0.808	95°C
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Manufactured from butylene, a gas produced in the "cracking" of gasoline, also made by the hydrogenation of methyl ethyl ketone. Where such factors as price are concerned, the use of this product is advocated in conjunction with butyl alcohol. Proportionate amounts will vary in consideration of whether the finished lacquer is to be used in or outdoors. Often essential oils are incorporated in an attempt to "sweeten" the residual odor.

NORMAL BUTYL ALCOHOL BUTANOL	BUTYL ALCOHOL, NORMAL $CH_3CH_2CH_2CH_2OH$	0.812	100°C
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Efforts directed toward the production of acetone for wartime use developed butyl alcohol. This product laid the foundation of the present day lacquer industry with respect to nitrocellulose solvents. Normal butyl acetate is prepared from this alcohol. Butyl alcohol is based on the fermentation of starch by the bacteria which is technically known as "clostridia acetabutylicum." This bacteria were discovered by Dr. Chaim Weizmann. The bacterial fermentation produces the butyl alcohol, acetone, and ethyl alcohol. During the fermentation, carbon dioxide and hydrogen are evolved and these gases are transformed, catalytically, into methanol. Corn is used as the source of starch for the fermentation. The manufacturing process is divided into four steps: (a) preparation of the corn; (b) propaga-

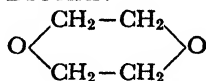
tion of the bacteria; (c) fermentation; and (d) distillation. Butyl alcohol is also manufactured from acetaldehyde.

Butyl alcohol is a high boiling latent solvent which retards the evaporation of the volatile content of lacquer. It is completely miscible with all lacquer solvents. This has a marked bearing on producing "flow." It is an effective anti-blush agent and prevents moisture precipitation because of its high solvation with relatively small proportions of an ester. Its retentivity in a lacquer film is therefore retained as solvent properties. It forms constant boiling mixtures with water. Butyl alcohol is therefore useful as a dehydrating agent.

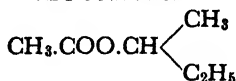
DIOXAN

DIOXAN

1.037 101°C



Produced by the reaction of ethylene gas. A cellulose acetate, ethyl cellulose, resin and wax solvent. When used as a constituent of lacquer, it is used in conjunction with alcohol.

**SECONDARY BUTYL
ACETATE**BUTYL ACETATE
SECONDARY0.863 102°C
@ 25°C

The raw material for this product is produced from a petroleum base, which accounts for the difference in odor from that of the normal solvent. Secondary butyl acetate produced from secondary butyl alcohol and acetic acid bear the same relationship to normal butyl acetate as secondary butyl acetate does to normal butyl alcohol. The boiling range and rate of evaporation, however, is lower than the normal product. Advantage in their potential use is price, which is approximately 70% of the normal product. Slightly less solvent power than the normal.

AMYL ACETATEAMYL ACETATE
 $\text{CH}_3\text{COOC}_5\text{H}_{11}$

0.867 110°C

Manufactured by the esterification of acetic acid with amyl alcohol. Amyl acetate had the distinction of being the first solvent used in the manufacture of lacquers. There are various grades available

which are controlled by the grade of fusel oil (amyl alcohol) used and is usually purchased on its respective boiling range and ester content. Amyl acetate is a higher boiler which will permit of great dilution with low boiling esters and non-solvents. Retards blushing and produces "flow-out" of films.

BUTYL PROPIONATE	BUTYL PROPIONATE	0.873	116°C
	$\text{CH}_3\text{CH}_2\text{COO.C}_4\text{H}_9$		

Butyl propionate was formerly made by the fermentation process from kelp, a Pacific coast seaweed, but it is now made from butyl alcohol. This product is one of the high boiling solvents often used in lacquers to increase the flow and to prevent "blushing," and in place of amyl acetate. It has found satisfactory usage in brushing lacquers because of its retardent nature. In solvency, this product closely resembles butyl and amyl acetates. It is non-hygroscopic.

SYNTHETIC AMYL	AMYL ALCOHOL,		
ALCOHOL (PENTASOL)	SYNTHETIC from Pentane	0.816	116°C
	$\text{C}_6\text{H}_{11}\text{OH}$ — mixture of isomers		

The synthesis of amyl alcohol from pentane has increased the production of this synthetic product and, with production costs lowered, the use has been greatly expanded. Pentasol finds great favor in the lacquer industry and is used expressly for its blush retarding feature.

AMYL ALCOHOL	METHYL PROPYL		
	CARBINOL	0.810	118°C
	$\text{CH}_3\text{CH}_2\text{CH}_2$		
	$\begin{array}{c} \text{CH}_3 \end{array} \begin{array}{c} \diagup \\ \diagdown \end{array} \begin{array}{c} \text{CHOH} \end{array}$		

METHYL CELLOSOLVE	ETHYLENE GLYCOL		
	MONO METHYL ETHER		
	$\text{H}_2\text{C}-\text{OH}$		
	$\text{H}_2\text{C}-\text{OCH}_3$		

A nitrocellulose, cellulose acetate, and resin solvent. Lower boiler in the ethylene glycol series of solvents.

BUTYL ACETATE	BUTYL ACETATE	0.876	120°C
	$\text{CH}_3\text{COO.C}_4\text{H}_9$		

Made by the esterification of acetic acid with butyl alcohol, using H_2SO_4 as a catalyst. It is surpassed only by ethyl acetate as an ester.

Classed as a medium boiling solvent and is therefore more blush resistant than ethyl acetate. Is miscible in all proportions with lacquer solvents. Considered the most important solvent used in the manufacture of nitrocellulose lacquers. A solvent for nitrocellulose, also resins. Butyl acetate is of non-hygroscopic nature.

DIETHYL CARBONATE (DIATOL)	DIETHYL CARBONATE (C_2H_5) ₂ CO ₃	0.961	120°C
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A synthetic product comparable with normal butyl acetate in properties. A medium boiling nitrocellulose and resin solvent.

SECONDARY AMYL ACETATE	AMYL ACETATE, SECONDARY CH ₃ COOC ₆ H ₁₁	0.861	120°C
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A product having a relatively higher boiling point and a lower rate of evaporation than the normal butyl acetate, but the price is quoted under that of normal butyl acetate. This factor should permit volume consumption. Usual secondary odor.

PENTACETATE	AMYL ACETATE, SYNTHETIC from Pentane CH ₃ .COO.C ₆ H ₁₁ (mixture of isomers)	1.865	126°C
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An ester made by the acetylation of pentasol (synthetic amyl alcohol) with acetic acid. A nitrocellulose and resin solvent of high standard. Will permit a greater non-solvent and low boiling ester addition than the normal amyl acetate.

CELLOSOLVE	ETHYLENE GLYCOL MONO ETHYL ETHER CH ₂ OH.CH ₂ OC ₂ H ₅	0.931	128°C
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A nitrocellulose solvent of great power. A high boiler having high dilution ratio and toluol dilution factor. Used in brushing lacquers and for interior work where odor is an item. It is considered an odorless solvent.

DIACETONE	DIACETONE CH ₃ COCH ₂ C(CH ₃) ₂ OH — 4 hydroxy 2 keto 4 methyl pentane	0.939	130°C
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Diacetone is prepared from acetone. It is a good nitrocellulose and cellulose acetate solvent, also a resin solvent. Because of its alcoholic qualities, it finds a satisfactory outlet in cellulose acetate solutions.

ETHYL LACTATE	ETHYL LACTATE (CH ₃ CH(OH)COO.C ₂ H ₅)	1.024	137°C
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Manufactured by the esterification of lactic acid with ethyl alcohol and is considered a close approach to the ideal solvent. Also produced by reaction with ethylene gas. Has a very high dilution ratio with hydrocarbons. A very good high boiling solvent for nitrocellulose and cellulose acetate. Ethyl lactate is a blush preventative of a high degree. Permits good leveling of a lacquer film. Exerts a great deal of solvation which may be attributed to its alcoholic properties as well as its common consideration as an ester. It is used to a great extent in flow coating, brushing, and roller coating lacquers.

AMYL ALCOHOL	BUTYL CARBINOL, NORMAL CH ₃ (CH ₂) ₄ OH	0.817	137°C
ETHYL OXYBUTYRATE	ETHYL OXYBUTYRATE (CH ₃) ₂ COHCOOC ₂ H ₅	0.983	138°C

The ethyl ester is a hydroxyisobutyrate. A high boiling nitrocellulose and cellulose acetate solvent produced by the reaction with ethylene gas. A preventative of "blushing."

BUTYL BUTYRATE	BUTYL BUTYRATE C ₄ H ₉ OOCC ₄ H ₉	0.872	138°C
CELLOSOLVE ACETATE	ETHYLENE GLYCOL MONOETHYL ETHER ACETATE CH ₂ OC ₂ H ₅ .CH ₂ C ₂ H ₃ O ₂	0.980	145°C

A nitrocellulose solvent of great power, high blush resistance, and produces good leveling to films. It produces a greater dilution ratio than cellosolve and imparts a high gloss to a lacquer film.

CYCLOHEXANONE	CYCLOHEXANONE C ₆ H ₁₀ O	0.947	150°C
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A nitrocellulose, cellulose acetate and resin solvent having a great dilution ratio with cheaper and low boiling solvents.

FURFURAL	FURFURALDEHYDE	1.160	150°C
	CH = C.CHO		
	$ \begin{array}{c} \qquad \diagup \text{O} \\ \text{CH} = \text{C} \\ \text{H} \end{array} $		

Prepared from corn cobs by steam digestion with sulphuric acid. May also be prepared from oat hulls. A high boiling solvent which prevents "blushing" and produces good leveling of films. It is an excellent nitrocellulose and cellulose acetate solvent. It has an objectionable odor which limits its use in coating films. Furfural is used in the manufacture of synthetic resins and these phenol-furfural resins are infusible and insoluble, having high insulating properties. Furfural darkens in the presence of light.

HEXALIN	CYCLOHEXANOL or HEXAHYDROPHENOL $\text{C}_6\text{H}_{12}\text{O}$	0.954	154°C
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A secondary alcohol prepared by the hydrogenation of phenol or carbolic acid in the presence of nickel. A preventative of blushing under very severe conditions. Hexalin produces an even flow to films, free of "orange peel" because of its high evaporation rate.

SECONDARY HEXYL- ACETATE	HEXYLACETATE, SECONDARY $\text{C}_4\text{H}_9\text{CH}(\text{OOCCH}_3)\text{CH}_3$ $\text{CHCH}_2\text{CH}(\text{OOCCH}_3)\text{CH}_3$ $\begin{array}{c} \\ (\text{CH}_3)_2 \end{array}$	0.855	155°C
	70% 30%		

A solvent used in nitrocellulose lacquer emulsions.

BUTYL LACTATE	BUTYL LACTATE $\text{C}_3\text{H}_7\text{O}_2\text{C}_4\text{H}_9$	0.978	155°C
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An excellent nitrocellulose and resin solvent, manufactured by the esterification of lactic acid with butanol. It exerts good solvation on nitrocellulose, a blush preventative and permits a great degree of dilution with hydrocarbons. Produces a film with good leveling properties, practically odorless, and has an evaporation rate one-tenth that of amyl acetate. Used in brushing lacquers in which it has been

found that it will not raise the second coat application, also used in flow coating, stencil printing, and where a retarded drying is necessary.

BUTYL CELLOSOLVE	ETHYLENE GLYCOL	0.902	163°C
	MONOBUTYL ETHER $\text{CH}_2\text{OHCH}_2\text{OC}_4\text{H}_9$		

Butyl cellosolve is the highest boiler in the ethylene glycol series. It is a nitrocellulose and resin solvent which shows high film retentivity and a somewhat slow solvent action.

METHYL HEXALIN	METHYL CYCLOHEXANOL $\text{C}_7\text{H}_{14}\text{O}$	0.924	165°C
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A higher boiling solvent than cyclohexanone, having good solvent properties.

DIISOBUTYL KETONE	DIISOBUTYL KETONE $(\text{CH}_3)_2\text{CHCH}_2(\text{CO})\text{CH}_2\text{CH}(\text{CH}_3)_2$		168°C
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A high boiling solvent for nitrocellulose and synthetic resin coatings. It is insoluble in water.

HEXALIN ACETATE	HEXAHYDROPHENOL ACETATE $\text{C}_8\text{H}_{14}\text{O}_2$	0.966	175°C
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Hexalin acetate resembles amyl acetate and is an excellent solvent for nitrocellulose and cellulose acetate. It is a good blush preventative and possesses a great dilution ratio.

FURFURYL ALCOHOL	FURFURYL ALCOHOL $\text{CH} = \text{C} \cdot \text{CH}_2\text{OH}$ $\begin{array}{c} \quad \diagup \text{O} \\ \text{CH} = \text{C} \quad \text{H} \end{array}$	1.1351	177°C
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A good resin solvent, water white in color, of mild odor. Furfuryl alcohol darkens upon exposure.

CARBITOL	DIETHYLENE GLYCOL	1.025	180°C
	MONOETHYL ETHER $\text{H}_2\text{C}-\text{O} \cdot \text{C}_2\text{H}_5$		
	$\begin{array}{c} \\ \text{H}_2\text{C}-\text{O} \cdot \text{CH}_2\text{CH}_2\text{OH} \end{array}$		

A nitrocellulose and resin solvent, hygroscopic and of oily-like

nature. Carbitol has a low rate of evaporation and is sometimes used in wood stains.

ETHYL ACETYL GLYCOLATE	ETHYL ACETYL GLYCOLATE $C_6H_{10}O_4$	1.094	181°C
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An odorless, high boiling solvent for nitrocellulose and cellulose acetate.

DIETHYL OXALATE	DIETHYL OXALATE $(COO.C_2H_5)_2$	1.077	185°C
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Prepared by the esterification of oxalic acid and purified by distillation.

OCTYL ACETATE	OCTYL ACETATE $C_4H_9CH(C_2H_5)CH_2OOCH_3$	0.862	199°C
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Used in lacquer emulsions.

BENZYL ALCOHOL	BENZYL ALCOHOL $C_6H_5CH_2.OH$	1.045	204°C
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Benzyl alcohol is a product of toluene by hydrolysis and chlorination. Offers a satisfactory wetting action to pigments and suggested as a pigment grinding medium. Its high dilution ratio permits the addition of great amounts of cheaper non-solvents. It is highly compatible with influences governing the smaller range of cellulose acetate liquids. Improves the flow of a cellulose acetate lacquer film and is recommended in flow-coating lacquers.

TETRALIN	TETRAHYDRONAPH- THALENE $C_{10}H_{12}$	0.977	205°C
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A solvent for resins and waxes, made by the catalytic hydrogenation of naphthalene.

BENZYL ACETATE	BENZYL ACETATE $C_6H_5CH_2COOCH_3$	1.055	213°C
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An exceptionally high boiling and low evaporating nitrocellulose solvent which exerts great power of solvation on nitrocellulose and shows a great dilution with low boiling solvents.

BUTYL CARBITOL	DIETHYLENE GLYCOL		
	MONOBUTYL ETHER	0.960	215°C
	$\text{CH}_2.\text{O}.\text{C}_4\text{H}_9$		
	$\text{CH}_2.\text{O}.\text{CH}_2.\text{CH}_2.\text{OH}$		

A nitrocellulose, cellulose acetate and resin solvent, having high film retentive properties.

BENZYL BENZOATE	BENZYL BENZOATE	1.100	320°C
	$\text{C}_6\text{H}_5\text{COO}.\text{CH}_2\text{C}_6\text{H}_5$		

Benzyl benzoate resembles amyl acetate in a general way. It is, however, of a much higher boiling range and has greater film retentive properties. It is most generally used in conjunction with plasticisers.

Aromatic Hydrocarbons

BENZOL	BENZENE	0.874	78°C
	C_6H_6		

A resin solvent, also an ethyl cellulose solvent in the presence of alcohol, which is prepared from coal tar light oil. Benzol is a lacquer diluent which, because of its toxicity, is little used. It is not to be confused with benzine.

TOLUOL	TOLUENE	0.864	110°C
	C_7H_8		

A by-product from the coking of coal. Quite widely used in lacquer manufacture as a diluent, a satisfactory resin solvent.

XYLOL	XYLENE	0.864	132°C
	C_8H_{10}		

Used as a diluent for lacquers and quite extensively as a solvent for synthetic enamels.

PETROLEUM HYDROCARBONS — Among the more widely used fractionations are such products as: lactol spirits, troluoil, B & L thinner, diluent "C," etc. These products find great promise in the industry and are used extensively as a part replacement for toluol. Petroleum hydrocarbons are also used in synthetic enamels but are of a higher boiling range than those mentioned above.

TURPENTINE AND PINE OILS — Experiments as solvents and in con-

junction with thinners for nitrocellulose lacquers as compared with coal tar hydrocarbons would indicate comparable partial solvent properties, or colloidal properties, in proportions of 75% to 25% of an ester. They are, however, used to very little extent in lacquer and synthetic enamels.

SOLVENTS FOR CELLULOSE ACETATE — Among the common solvents for cellulose acetate may be mentioned: acetone, methyl acetone, ethyl lactate, diacetone and, within less wide limits, ethyl acetate, ethyl methyl ketone, methoxyethyl alcohol (methyl cellosolve). Typical non-solvents or diluents are: ethyl alcohol, benzene, xylene, toluene, butanol and cyclohexane.

With respect to the changes in solubility properties of cellulose acetate as the acetyl content decreases, there are several factors which may be considered. In cellulose acetates of high acetyl content, the addition of even small quantities of water to acetone solutions results in an immediate rise in viscosity, whereas, as the acetyl content becomes lower, the amount of water which may be added before an increase in viscosity is observed, is much higher. There is, in fact, a minimum viscosity obtainable by additions of water to acetone used in the preparation of such solutions. Whereas cellulose acetate of high acetyl content is only swelled in hot aqueous alcohol (75%), cellulose acetates of low acetyl content are easily dispersible by aqueous ethanol at 85°C, when the concentration is in the range of 75% ethanol.

With reference to ethyl methyl ketone, cellulose acetates of high acetyl content give very grainy solutions, but as the acetyl content decreases, the solutions in ethyl methyl ketone become more uniform and its solvent power apparently improves. In the case of chlorinated hydrocarbons, cellulose acetate is not dissolved by ethylene chloride at ordinary temperatures, but upon the addition of a few per cent of alcohol, it is readily taken into solution. However, when a sufficient amount of alcohol has been added, the viscosity again increases, so that when this latter reagent predominates, the cellulose acetate is no longer soluble in the mixture. It is found that at higher acetyl contents, the limits of alcohol concentration are much more circumscribed than for cellulose acetates of lower percentages of acetyl.

It may also be of interest to note that when alcohols are used in

cellulose acetate solvents, the increase in length of the carbon chain, as the higher members of the homologous series are used, tends to show increasingly the properties of hydrocarbons of comparable chain length, with the effect of the hydroxyl group diminishing as the chain becomes longer.

The ratio of active solvent to non-solvent must be higher in the case of cellulose acetate than for cellulose nitrate, and the minimum may approximate 7 parts solvent to 3 parts non-solvent. These should be selected in such proportions that the mixture remains a solvent or at least a gelling agent as the lacquer film dries, with perhaps the presence of a small quantity of a high boiling solvent to impart clarity and gloss to the film. The purpose of this high boiler is indirectly to prevent precipitation of the ester due to absorption of moisture by condensation or cooling, and later, as the high boiler evaporates, to carry with it that moisture. Furthermore, by allowing the film to remain plastic for an extended period, the high boiler assists in imparting gloss to the lacquer film. In general, it may be said that solvent combinations for cellulose acetate will dissolve cellulose nitrate, but the reverse is not necessarily true.

REFERENCE

(4) *Farben Ztg.*, 36-1300 (1931).

PLASTICISERS

The word "plasticiser" is taken from the term "plastic" or "pliable" and is regarded as a retainer in a pliable form. Plasticisers in this sense are substances which tend to increase the flexibility or elasticity; they are usually esters.

As set forth in Chapter I (genealogy), the early development of nitrocellulose lacquers was considerably retarded because of the lack of proper type plasticisers. With further reference to early developments, the Celluloid Corporation is cited for its part in the growth of the lacquer industry. Celluloid Corporation's increasing efforts in conjunction with the nitrocellulose plastics and later development of tricresyl phosphate made it possible for the industry to overcome such deficiencies as were found in the early type of lacquers.

Plasticisers may be considered as exceptionally high boiling solvents which remain permanently in a lacquer film. Without plasticity or pliability, the film so formed would be without "life." The addition of plasticisers to lacquers decreases the tensile strength and increases the elongation of the film. It is the further function of plasticisers to increase the flow of the lacquer just before it sets, to produce a level film and to prevent blushing.

There are two general terms applied to plasticisers: oils and chemicals. The former, because of improper dispersing qualities, are less frequently used. They also sweat out in the film and tend to become acid and quite rancid. Oils are referred to as plasticisers, flexilizers or softeners. Chemical plasticisers are most frequently used in lacquer

formulation and in general overcome the deficiencies pointed out above. Their functions are discussed at some length throughout this chapter.

The volatility of plasticisers has an important bearing on their relative use in lacquers. Plasticisers in this respect are referred to in connection with lacquers used in coatings for protective and decorative purposes and not as plastic compounds. A true nitrocellulose plasticiser should be of a non-volatile nature under conditions whereby lacquer is employed. There are two general classes of plasticisers used in lacquers which are termed "permanent" and "temporary." The vapor tension of the former is quite low which makes them a true constituent of the film, while the latter may be considered of higher vapor tension or of volatile nature and act more so as a solvent for nitrocellulose, having only partial plasticising properties. High boiling solvents, which are termed "temporary" plasticisers, aid remarkably in blush resistance. At the same time, the entire compatibility and partial solvent properties of nitrocellulose and its components are desired. The true plasticiser must have solvent properties for resins present in lacquers, through which miscibility will tend to produce the desirable features so formed. Factors which influence film tendencies toward brittleness depend on volatility of solvents. When a partial plasticiser may enter into a given lacquer film, being of medium or high vapor tension, the film thus formed would become unsatisfactory as a coating medium because of the tendencies of such a film to become brittle. A properly plasticised lacquer film should contract and expand and thus overcome brittleness. High boiling solvents that are termed temporary plasticisers include the range of familiar products of today, e.g., ethyl and butyl lactate, amyl alcohol, hexalin, cellosolve acetate, etc. These solvents are of lower vapor tension than the wider range of low and medium boiling solvents so prevalent in lacquer formulation. While these high boiling, low vapor tension solvents retard the drying of lacquer films and produce satisfactory leveling, they eventually leave the film after the low and medium boiling solvents have evaporated. They are not as effective in adding plasticity, toughness or elasticity to films as the permanent type of plasticisers. Most plasticisers are liquids while two or three frequently used are solids. While plasticisers aid in adherence through

elasticity, the resins employed have a like effect on the adhesion of lacquer films. The use of synthetic resinous compounds has great bearing on the adhesion of applied films. Indications therefore lean toward plasticiser corrections and lesser amounts used when and if synthetic resins are employed in lacquer films. Pigmented lacquers require relatively more plasticiser than clear lacquers. The difference in oil absorption of chemical pigments over the basic earthen type necessitate adjustment in this respect.

Plasticisers must have a marked influence on the flow of a given lacquer through its retarding action on the active solvents present, and in like manner have an effect on the resulting gloss. The use of low and medium boiling solvents in conjunction with high boiling plasticisers is therefore advocated. Plasticisers must be entirely compatible with all forces affecting the performance of a given lacquer. This compatibility affects the film formation and yields an even surface which permits the "leveling-out" of the film.

The following should be considered in the selection of plasticisers:

- (a) Non-volatile at applied temperatures.
- (b) Good nitrocellulose solvent.
- (c) Miscible with all lacquer solvents.
- (d) Odorless.
- (e) Colorless.
- (f) Neutral in character.
- (g) Non-hygroscopic and immiscible with water.
- (h) Impart gloss to the film.
- (i) Have sufficient body to be adapted for grinding of pigments.

Plasticiser effects on "baking lacquers," when nitrocellulose films are subjected to high temperatures, indicate that there is no retardation toward decomposition. Lacquers based primarily on nitrocellulose, however, should not be subjected to elevated temperatures. Chemical plasticisers, being true nitrocellulose solvents, when added to lacquers and subjected to heat, show a marked brittleness of the film. On the other hand, various non-drying oils which are compatible with nitrocellulose and which may be employed in a coating film, may be heat-treated for long periods and will overcome film brittleness. This leads up to the use of oil modified synthetic resins

which have in their structure sufficient oils to prolong baking of lacquer films (5).

Properties of Some Plasticisers

<i>Commercial Name</i>	<i>Chemical Name and Formula</i>	<i>Sp. Gr.</i>	<i>Boiling Point</i>
CAMPHOR	CAMPHOR $C_{10}H_{16}O$	1.99	209°C

Camphor is used mostly in celluloid manufacture and when used in lacquers, it enters in sparing amounts. A film in which camphor is present seems to lack cohesiveness. If used in wood lacquers in too great quantities, it causes film ruptures with the run-of-the-grain of the wood. Camphor shows a pronounced solvent action on dry nitro-cellulose.

BUTYL STEARATE	BUTYL STEARATE $CH_3(CH_2)_{16}.COO.C_4H_9$	0.856 @ 25°C (25 mm.)	220°C
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Butyl stearate is manufactured from stearic acid and butanol. It is a fatty acid ester having no solvent power on lacquers; in this respect, it acts similar to castor oil. Usually enters nitrocellulose lacquers in combination with other plasticisers, highly hygroscopic, becomes solid at 20°C, but does not crystallize in lacquers. It exerts polishing properties to lacquer films.

TRIACETINE	GLYCEROL TRIACETATE $(C_2H_3O_2)_3C_3H_5$	1.16 @ 20°C	258°C
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A nitrocellulose and cellulose acetate plasticiser manufactured from glycerine and acetic acid. It is used to incorporate alkyd and vinyl acetate resins with cellulose esters. Triacetine does not develop acidity.

DIMETHYL PHTHALATE	DIMETHYL PHTHALATE $C_6H_4(COO.CH_3)_2$	1.19	282°C
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A phthalic acid ester manufactured from methyl alcohol and phthalic anhydride. It is a plasticiser for cellulose acetate.

BUTYL TARTRATE	BUTYL TARTRATE $(CO_2C_4H_9)_2(CHOH)_2$	1.082	292°C
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An oily and colorless liquid manufactured from tartaric acid and butanol. It is used generally with triphenyl phosphate or tricresyl

phosphate when employed in nitrocellulose lacquers. It finds a greater outlet as a cellulose acetate plasticiser.

DIETHYL PHTHALATE	DIETHYL PHTHALATE	1.12	295°C
	$C_6H_4(COO.C_2H_5)_2$		

A phthalic acid ester manufactured from ethyl alcohol and phthalic anhydride. It is used mostly as a plasticiser for cellulose acetate, but may also enter nitrocellulose lacquers. It is also used as a denaturant for specially denatured alcohol.

DIBUTYL PHTHALATE	DIBUTYL PHTHALATE	1.04	340°C
	$C_6H_4(COO.C_4H_9)_2$	@	
		20-20°C	

A phthalic acid ester manufactured from butanol and phthalic anhydride. It approaches the ideal plasticiser for nitrocellulose, but cannot be used in cellulose acetate lacquers. Dibutyl phthalate remains in the lacquer film permanently, retaining the plasticity of the film. It is a stable product that can be adapted as a pigment grinding vehicle and a softener in resin lacquers.

LINDOL	TRICRESYL PHOSPHATE	1.18	>275°C
	$(C_6H_4CH_3)_3PO_4$	@	
		10 mm.	
		Hg	

Tricresyl phosphate is one of the oldest and most widely used lacquer chemical plasticisers. It is also marketed under the trade names of Lindol "A" and Lindol "B," which are technical grades. It is a phosphoric acid ester manufactured of cresylic acid and phosphorous oxychlorides, mixed in molecular proportions and heated in retorts. Upon completion of the reaction, the crude product is distilled and purified. It forms permanent flexible, stable, non-shrinking, adhesive and glossy films, corrects blushing, produces hard waterproof films which react easily to polishing, reduces chalking in pigmented films and reduces flammability of the formed film.

DIAMYL PHTHALATE	DIAMYL PHTHALATE	1.02	344°C
	$C_6H_4(COO.C_6H_{11})_2$		

A phthalic acid ester manufactured from amyl alcohol and phthalic anhydride. It is a nitrocellulose ester which resists blushing and pro-

duces lacquer films of higher tensile strength than the lower phthalates.

TRIPHENYL PHOSPHATE	TRIPHENYL PHOSPHATE (C ₆ H ₅) ₃ PO ₄	1.19	>320°C @ 10 mm. Hg
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A phosphoric acid ester which is a white to amber colored crystalline solid. It has a tendency to crystallize in the lacquer film and for this reason it is seldom used in lacquer formulation. The crystallizing tendency may be overcome if used with a small quantity of a second plasticiser. It is used in cellulose acetate lacquers in conjunction with tricresyl phosphate.

AMYL TARTRATE	AMYL TARTRATE CH(OH).COO.C ₆ H ₁₁ CH(OH).COO.C ₆ H ₁₁	1.055 @ 15°C	400°C
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A nitrocellulose and cellulose acetate plasticiser which, through excessive cost prohibits widespread use.

TRIBUTYL PHOSPHATE	TRIBUTYL PHOSPHATE (C ₄ H ₉) ₃ PO ₄	0.973 @ 20°C	177°C @ 27 mm. Hg
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A water white plasticiser of low vapor tension, insoluble in water but soluble in lacquer solvents. It is compatible with other plasticisers and is an excellent solvent and colloidizing agent for nitrocellulose. Plastics made with tributyl phosphate remain flexible at low temperatures and are odorless and stable toward light. This product suggests an outlet with vinyl acetates in conjunction with nitrocellulose.

ETHOX	ETHOXY OTHY- PHTHALATE COO.CH ₂ CH ₂ O.C ₂ H ₅ COO.CH ₂ CH ₂ O.C ₂ H ₅
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This is a recently introduced plasticiser having a toluol dilution factor said to be 25% higher than dibutyl phthalate. It possesses characteristics of a true solvent for nitrocellulose and lower evaporation rate than some of the lower phthalates.

AROCLORS

The aroclors are softeners for lacquers and are recommended as softener-resin combinations. They are not subject to polymerization, rancidity, etc., and they possess the advantageous property of weather resistance.

CASTOR OIL, C.P.
AND BLOWN

TRIGLYCERIDE OF
RICINOLEIC ACID . 0.962

A non-drying oil which is a non-solvent for nitrocellulose. It is more correctly referred to as a softener and produces a weak lacquer film. While no change has been noted on oxidation, it sweats out of a lacquer film, becomes rancid and causes acidity. The blown oil is more frequently used than the raw oil and proportionate amounts of the blown with dibutyl phthalate will exert solvation on nitrocellulose. Castor oil blends well with nitrocellulose and resins, and for best results should be heated with plasticiser or high boiling solvents before being added to the lacquer base. Castor oils are used in pigment dispersion and retain their fluidity through temperature changes.

SULFONATED CASTOR OIL

This sulfonated oil is used in lacquer emulsion work.

CHINAWOOD OIL

Chinawood oil dries by oxidation and polymerization, has an unpleasant odor and is used sparingly in lacquer formulation.

COTTONSEED OIL

Blown cottonseed oil is used sparingly in lacquers which are subjected to high temperatures. The fatty acids of this oil are used in the manufacture of synthetic resins.

COCOANUT OIL

A water white to light amber solid having a low melting point. The fatty acids of this oil are used in the manufacture of synthetic resins. Attempts have been made to use this oil in various lacquer formulae, but have met with little success. The "pressed oil" (with stearine removed) appears to be more compatible than the whole oil.

LINSEED OIL

Of the available varnish oils, this oil presents the greatest possibility for use in lacquers. At present, it is little used because the character of the lacquer so formed is subject to change over a period of time. Recently ADM No. 100 Linseed Oil has been produced by Archer Daniels Midland Company and has met with the lacquer manufacturers' approval. It is entirely compatible with lacquer products. The fatty acids of this oil are used in the manufacture of synthetic resins.

RAPESEED OIL

The blown oil finds an outlet in the leather industry and is used in heat resisting lacquers and in synthetic resin manufacture. This oil does not oxidize and is slow to become rancid or acid and for this reason finds greater preference than the castor oils.

PLASTICISERS FOR CELLULOSE ACETATE

As in the case with cellulose nitrate, the addition of plasticisers to cellulose acetate imparts flexibility to thin sheets or films, and in the case of molding compounds, aids in permitting the use of lower temperatures and pressures. While the number of plasticisers available for cellulose acetate may not be as great as for cellulose nitrate, there are hundreds of compounds which have been successfully used; the choice depending largely on the industrial application of the product. Among such may be mentioned the organic esters of phosphoric acid, such as: tricresyl phosphate, triphenyl phosphate, and tributyl phosphate; the organic esters of phthalic acid, such as: ethyl and methyl phthalate, and many others, such as: triacetine and the esters and amides of toluene sulphonc acid. Some of these are solvents for cellulose acetate, particularly at elevated temperatures, others are not, and the superior efficacy as a plasticiser of either class is a moot question; some contending that the solvent type plasticisers offer advantages not to be found in those which are of the non-dispersing group. It should be added that cellulose acetate manufactured under well-controlled conditions does not require the use of stabilizer since its inherent stability is such as to require nothing

of this sort to enable it to retain its properties, even under high temperature conditions.

REFERENCE

(5) Circular 383, June 1931 of American Paint and Varnish Manufacturers Association, "Some properties of lacquer plasticisers in nitrocellulose films and solutions."

RESINS

Gums or resins (necessarily a true constituent of nitrocellulose lacquers) perform the function of adhesion to an applied surface, increase the lustre, permit rubbing of the film to a relatively richer depth, and add solids or film building properties. In the instance of synthetic resinous compounds, they perform the combined function as mentioned above, in addition to adding partial plasticising properties.

Gums or resins are of three general types:

- (1) FOSSIL RESINS — Exudations from living trees of centuries ago, which have become hardened or fossilized throughout the years. These gums are noted for their hardness.
- (2) MODERN GUMS OR RESINS — Exudations from living trees of modern times. These are softer than the fossil gums.
- (3) SYNTHETIC RESINS — Chemical reaction products which are mechanical reproductions, having the combined functions of the natural product.

In dealing with the subject of resins, an attempt will be made to revert to the oldest known gums or resins; deal with shellac, which is identified with the first type of gum solution used in modern lacquers; mention the various fossil gum-resins that are used and some of the synthetic resins in use today.

ASPHALT

Thousands of years before the dawn of Christianity, this resinous substance was serving the needs of mankind. Throughout the ages

it has bearing on world's development. The Bible tells us of its use in (Genesis 6:14), where it was used on the historic Ark and again in (Exodus 2:3), where reference is made to the use of "pitch" as a coating on the basket in which Moses was found. In ancient days this substance was used as a preservative or waterproofing for boats and also for street paving. The ancient Egyptians used it to preserve their mummies and mummy cases. Examination of recent excavations has disclosed a remarkable state of preservation after thousands of years of earth captivity. The La Brea asphalt pits in Southern California have yielded rare fossils of prehistoric animals trapped in its asphalt beds. Asphalt has been referred to as a gum or resinous substance while in reality it is a mineral and often referred to as a fossil bitumen. It is one of the oldest minerals known to mankind. With reference to asphalt and its association in lacquer, such a product enters into nitrocellulose lacquers as "Gilsonite," which is a glossy black, lumpy form and is comparable in appearance with a lump of bold fossil gum or resin. Gilsonite has been used as a media to produce lustrous black finishes. The lump Gilsonite is usually prepared as a compatible varnish-lacquer base (a cooked varnish which is compatible with nitrocellulose lacquer); in the form of a paste or as a cold-cut solution. These mediums are soluble and entirely compatible with lacquers. Gilsonite is relatively cheap and to produce a dense and glossy black lacquer, it is customary to add carbon black pigment pastes. In this combination a semi-lustrous finish will result; however, a happy medium of selected lustre-producing ingredients will give very satisfactory results. Gilsonite has a brownish cast which is often objectionable in a lacquer. Blue pigment is often used to counteract this undesirable cast; such pigment may enter as a paste or is often added to the varnish kettle in the preparation of the compatible varnish-lacquer base. The finished product finds an outlet as chassis black in the motor car industry.

SHELLAC

This resin, of animal origin, is closely allied with the early development of nitrocellulose lacquers. Of the available series of varnish type resins at the outset of the present industry, many were objectionable for use in lacquers. Resins, like solvents, are added to a

lacquer in view of the duty the finished product is to perform. Today, combinations of various resins are used to secure these desirable results, while in the earlier days of nitrocellulose lacquers, shellac was the only available and satisfactory resin which performed the combined function believed desirable at that stage of lacquer development.

The term "shellac" is closely allied with the name "lacquer," which is in turn derived from the Hindustani word "lakh." This word means "a hundred thousand" and is assumed to be the connecting term associated with the myriad of minute insects that feed on the lac-tree and produce the product "shellac." Such a product may be the basis of the older Chinese varnish type materials often referred to as lacquer.

Shellac is a product of India and is the hardened secretion of minute insects which feed quite freely on the native tree commonly called the lac-tree. This secretion is dug from the earth and forms a product known as "shellac-gum."

Shellac enters the market in various grades: white and orange are the predominant varieties. The former for lacquer use should be freed of wax, refined, bleached and bone-dried. Because of the tendency of this resin to decompose on exposure, it should be dissolved as soon as possible upon its receipt. Shellac is subjected to a chemical change upon standing and as it ages becomes less soluble in alcohol. The shellac "cut" is usually carried on in a vertical stationary tank although often a horizontal rotating container is employed. The shellac cutters are usually constructed of wood, although metal is frequently used. Tank manufacturers have special wooden tanks constructed which are termed "shellac cutters."

REFINED DRY BLEACHED SHELLAC

This form is most commonly used in lacquers. It is of light color (lac dye and wax are removed). The bleaching of shellac consists of cutting in dilute solution of soda ash at moderate temperatures. The resin is taken in solution while the waxy precipitate remains in suspension. The wax is then removed by filtration. The solution of resin is bleached with sodium hypochlorite liquor; after bleaching, it is cooled and lac is precipitated with sulphuric acid. Impurities are

removed with water and the precipitated lac is cooked in water where the lac coalesces to a compact mass. The water is drained and lac is cut into large chunks — cooled, ground and dried.

The performance of shellac in lacquers has bearing on the solvents used in a given formulae. This is in view of only slight solubility with esters and hydrocarbons. Shellac is invariably dissolved in denatured alcohol (ethyl alcohol) although it gives a clear solution and film when dissolved in ethyl lactate or butyl cellosolve. In like manner, some shellac manufacturers will supply “cut shellac” to manufacturers’ specifications, i.e., a four or eight pound cut in denatured ethyl alcohol or butanol.

The advent of alcohol soluble nitrocellulose has presented a satisfactory outlet for cheaper lacquers which would permit the addition of great amounts of denatured alcohol and, incidentally, shellac in solution. The addition of an ester to insure complete solubility of the nitrocellulose is necessary, and unless great care is taken in the actual manufacture of such a lacquer, the large amounts of the required ester found necessary would have a bodying action in the presence of the added shellac.

The denaturant, pyridine, used in alcohols has been found to affect the odor of the solution. Metallic contact also has an effect on the solution if allowed to remain in such contact over an undue period. When shellac is dissolved in a metal tank, it should be drawn off as soon as it is completely dissolved.

Shellac solution as a trade commodity is sold as a three and one-half or four pound cut. It is sold in square varnish-type containers and frequently in glass bottles. To overcome the bodying action in the presence of tin containers, it is usually shipped in terne plate containers.

Shellac in the finishing industry has a myriad of uses. It is used as a sizing medium, sealer, and as a finishing coat. Its use as a sizing medium is in connection with materials of porous nature, e.g., canvas, felt, and cardboard. It is used as a sealer or undercoat under clear lacquers or varnishes, but it is not recommended as a sealer in the furniture finishing industry, because of its tendency to case-harden, cause bridging of films, brittleness, and cracking of films.

It is considered advisable to age the shellac cut before its addition

to lacquers and, when added to such lacquers, it is considered good practice to titrate in and always add the shellac cut as the last ingredient of the given formulae.

The present deluge of synthetic resins has partially been attributed to an attempt to manufacture a synthetic substitute for shellac.

DAMMAR

This resin has been universally used since investigation has proved its desirability in lacquers. During the earlier stages of lacquer manufacture, when the available varnish resins were under investigation, this resin received more favorable comment after a method of satisfactorily precipitating the waxy content was devised.

Dammar is a fossil resin which enters the trade in many grades; the Batavia and Singapore grades predominate. It is a product of the East Indies and is soluble in coal tar hydrocarbons and insoluble in alcohols. Dammar is also soluble in most esters.

Dammar gum-resins, for use in conjunction with lacquers, should be dewaxed before use. The solution is usually dissolved in a vertical mixer with a coal tar hydrocarbon; when dissolved, denatured alcohol is added which precipitates the waxy residue. The solution is permitted to settle and the clear solute is decanted. Iron mixers are generally used to dissolve the resin, although wooden mixers of the vertical type are also used. If the solution is to be used in pale lacquers or white lacquer enamels, a solution having been stored in wooden barrels is frequently used. Storage in metal tanks or drums will darken the solution. Dammar gum-resin enters the industry in many types of lacquer finishes, especially such finishes as may require mechanical rubbing. Such solutions produce a hard and tough finish. Dammar is most frequently used in conjunction with other resins, an example would be: dammar with ester gum (the former for adhesion, while the latter for lustre). Dammar resin in like manner is used in conjunction with synthetic resins. This resin produces very good tenacity in a lacquer film among the fossil resins.

KAURI

Kauri is a product of New Zealand and is soluble in esters and alcohols, but insoluble in toluol. It is a fossil gum-resin that is used sparingly in lacquer formulation because of its non-compatibility

with the generally used lacquer solvents and because of its high price.

Kauri is considered more durable than dammar and results in a harder film of still tougher nature than dammar. When kauri enters a given lacquer, it is usually dissolved with butyl acetate and alcohol, butyl alcohol or butyl cellosolve. Kauri is used where maximum adhesion is required and where heat resistance is a factor.

SANDARAC

This fossil resin is an African product and is a softer resin than kauri or dammar. It is frequently used as a substitute for shellac being completely soluble in denatured alcohol. It is not used in conjunction with nitrocellulose.

PONTIANAC

A fossil resin, a product of the East Indies, which finds an outlet in conjunction with the lacquer industry as a substitute for shellac and as a constituent of label varnish. It has a complete range of solubility, being soluble in esters, alcohols and hydrocarbons.

MANILA

This fossil gum-resin, like pontianac, is used in conjunction with straight gum lacquers. It is characterized by its stringy nature in solution and finds an outlet as a substitute for shellac, as a label varnish, and as the basis of spirit type zone marking coatings. It is soluble in alcohols and esters.

ELEMI

This resin has been used with nitrocellulose to a considerable extent. Entering a given lacquer formula in sparing amounts, it increases the flexibility and adhesion of a given lacquer film. It is soluble in alcohols, esters and coal tar hydrocarbons. Elemi is used in heat-resisting lacquers, usually with dammar solution; it also imparts a pleasing odor to the lacquer.

SYNTHETICS

The extensive research work in synthetic chemistry during and since the World War has been largely responsible for the development of the "synthetic resins" now satisfactorily used in lacquers and a basis for synthetic enamels. Synthetics were hastened through

the advancement in resin molding technique. Such compounds are allied with the thermo-setting type of resins, which, when subjected to heat and pressure, will set to an infusible and insoluble article. While the original use of these compounds was in the electrical field, the marked success achieved in this field sponsored the investigation of these resinous compounds in the paint, varnish and lacquer industry. The near depletion of available fossil resins, and the insistent demands of the industry for a faster drying finish, hastened this investigation to the point reached today. In connection with lacquer and its allied field, the first work was aimed at a substitute for shellac; while the actual approval was secured in conjunction with the varnish industry.

The synthetic resins are not an entirely new chemical development, as they have been known for some time. Space will not permit the history of this interesting subject. Many articles have appeared in the various trade journals as well as a very complete work: "The Chemistry of Synthetic Resins," 2 vols. (6), and "Synthetic Resins and Their Plastics," by Carleton Ellis (7), which details very thoroughly the history and chemistry of the subject. A book entitled, "The Chemistry of Synthetic Surface Coatings," by Dr. Knumbhaar (8) has also recently made its appearance.

The statement is often made that if the varnish industry had received the study that lacquers or synthetic resins have received, it is questionable whether they would have advanced to their predominant position of today. As mentioned earlier in this chapter, gums or resins add lustre, especially to pigmented lacquers; produce adhesion to a surface over which they may be applied (whether such a surface is wood, metal or previously applied undercoats) and favorably affect the strength and permanency of the film so formed. Resin added in solution form will effect a marked increase in film fullness or slight increase in viscosity where solids are introduced. Such gum or resin solutions will help to produce a film for rubbing. In the instance of synthetic-oil modified resins, the addition of "harder type" resins are necessary. Gum and oil supply the properties which tend to make the finished film resemble an oil varnish. The selection of resins is of great importance to the performance of the finished lacquer.

PHENOL FORMALDEHYDE RESINS

These are essentially reaction products of phenol compounds, such as phenol, cresol and xlenol with formaldehyde, paraformaldehyde or acetaldehyde to form resinous products. As previously indicated, these early products proved to be more suitable for molding, impregnating and insulating compounds, so that interest in them was diverted to this field. It was realized that these resins were very resistant to alkalis and acids, and would be of decided advantage in coatings if they could be produced in a form compatible with oils; therefore, with insistent demands from the coating industry, work was started to develop new resins. This work resulted in chemically combining such phenol resinoids with rosin and/or oils to produce compounds for use in varnish. These phenol formaldehyde condensates are of no use in lacquers, since they are infusible and insoluble in lacquer solvents of all types.

Commercial phenol resins are divided into four distinct groups, namely:

- (1) Phenol resins modified with natural resins.
- (2) Phenol resins modified with oils.
- (3) Straight phenol resins, heat reactive.
- (4) Straight phenol resins, permanently fusible.

Rosin Modified Phenol Resins

The resins in this group consist of compounds of phenols and aldehyde dispersed at the time of manufacture in esterified rosin. In view of the number of phenols and aldehydes which are available, and the possibilities of condensing and dispersing them by different methods and in different proportions, it can readily be appreciated that a variety of resins might be made.

One of the first and largest uses of these modified phenol resins is in quick drying water and weather resistant varnishes and enamels of the so called "four-hour" type which have to a large extent superseded for household use both brushing lacquer and the older types of slow drying finishes. They are also extensively used in modern fast schedule furniture varnishes. In addition they have of course found uses in a wide variety of industrial and other products. As a group

they are a close second to ester gum in total volume used by the coating industry.

Oil Modified Phenol Resins

The resins in this class are phenol formaldehyde condensations modified with fatty oils so as to make them suitable for varnish purposes. These resins are either viscous liquids or are offered in solution. They are generally heat reactive, so called because they become insoluble and infusible on heating, instead of melting. This heat-reactivity may be utilized during the further cooking with oils in varnishes, or it may be taken advantage of in baking coatings. For this reason the heat-reactive oil modified resins are used in water resistant baking undercoats and enamels. These oil modified resins are also frequently used in lacquers. In this class of oil modified resins is also found the 5 minute air-drying type used as primers and surfacers under lacquer.

Straight Phenol Resins, Heat Reactive

The resins in this group consist of phenol compounds which have been rendered oil-soluble and suitable for use in varnish making without dispersion in ester gum or oil, and which are hardened by heat instead of remaining permanently fusible. Therefore, when used in varnish they must not be overheated before being thoroughly dissolved in oils or other resins. These resins may be used in baking goods to take advantage of their drying by heat polymerization rather than by oxidation alone. They are also used to fortify ester gum and other soluble resins by their reactivity during the varnish cooking.

These straight phenol resins are classed separately from the modified phenol types, since they differ from them in composition and impart different characteristics to the products in which they are used. As in the other family groups which are being described, there are differences in the individual resins which should be borne in mind in selecting the one best adapted to any particular use.

Straight Phenol Resins, Permanently Fusible

The permanently fusible (non-heat reactive) types of straight phenol resins have found their greatest usefulness when cooked into

varnish with drying oils. When properly formulated such varnishes are quick drying, resistant to water, alkali, and abrasion and have good elasticity and durability. They can of course be used in either clear or pigmented form.

The moisture-proofness and chemical resistance of these resins has made them particularly useful in the field of metal primers and protective paint coatings. Certain of these unmodified phenolics may also be used in cellulose acetate and nitrate lacquers where increased waterproofness and resistance to fatty oils and dilute alkalies is required. Other resins in this general class are non-oxidizing, permanently flexible types suitable for plasticising nitrocellulose lacquer films.

AMBEROLS

The need for oil-soluble types was met by the early Amberols which were phenol formaldehyde resins modified with rosin, ester gum, etc. The advent of these resins hastened considerably the four-hour enamels. However, these grades were not entirely compatible with nitrocellulose because the phenol formaldehyde part of the resin was not compatible. Further research produced the so-called "100% phenol formaldehyde resins." These resins are reaction products of modified phenols with formaldehyde and/or paraformaldehyde and are not to be confused with phenol formaldehyde resins modified with ester gum, rosin, etc. Several of the "phenols" used in the manufacture of "100% phenol formaldehyde resins" are diphenyl phenol, para tertiary amyl phenol and para tertiary butyl phenol. The property of compatibility with oils has been achieved by "polarizing" phenol with various chemical groups which serve to decrease the chemical reactivity of the phenol and also draw it into solution with the oil. Amberol "modified phenol formaldehyde resins" are exemplified by the designation B S 1, F-7, K-12-A and No. 226 Amberol "unmodified" or "100% soluble" is exemplified by ST 137. These resins are used in varnishes and impart chemical resistance, durability and fast drying properties to the oil varnish. Amberol is the trade name of Resinous Products and Chemical Company.

BAKELITE

The Bakelite Corporation, who market products under the designation "Bakelite," offer quite a number of products as solid resins or in solution form:

- BR-1329 — 100% phenolic resin recommended for anti-corrosive primers.
- BR-3360 — 100% phenolic resin (hardened by heating) recommended for spar varnishes.
- BR-254 — Oil soluble phenolic resin recommended for spar varnishes, marine coatings and chemical resistant coatings.
- BR-2963 — Modified phenolic resin recommended for furniture rubbing varnishes.
- BR-2342 — Oil modified phenolic resin recommended for use in wood lacquers, particularly those that require high resistance to moisture and cracking (temperature changes).
- BR-3180 — Unmodified phenolic (50% solution in toluol) recommended for use in refrigerator lacquers. As this is a fairly flexible resin, less plasticiser is required as higher proportions of resin to nitrocellulose are used. However, since the lacquers become slower drying and softer as the proportion of resin is increased, $1\frac{1}{2}$ parts of resin to 1 part of nitrocellulose approaches the limit for general hardness. XR-3180 imparts high gloss to lacquers and possesses the property of retaining the high gloss on exposure. It is also noted for its moisture resistant properties.
- XR-9366 — Resin-modified phenolic for use in furniture lacquers, possessing excellent resistance to temperature change and printing.

It is recommended that the paper, "Specification methods for evaluating phenolic resin varnishes," by R. J. Moore and V. H. Turkington be read by all those interested (9).

BECKACITE

Modified phenolic resins and solutions which are a product of Reichhold Chemicals, Incorporated. Several types are:

- (1) Pure phenolic, No. 2000 super-Beckacite.
- (2) Modified phenolic, No. 1102 Beckacite.
- (3) Non-phenolic, No. 1111 Beckacite.

PHENAC RESINS

This type of resin belongs to Group 1 above, being compounds of various phenols and aldehydes dispersed at the time of manufacture in ester gum. These resins are known to the trade as Phenacs 622-N,

605-N, 615-N and 633-M, and are a product of American Cyanamid and Chemical Corporation.

SYNTHETIC RESINS FOR LACQUERS

Synthetic resins have been well received by the lacquer industry, fulfilling as they do all the necessary requirements of a resin. While the excessive addition of fossil resins to nitrocellulose increases the viscosity and shortens the life of the coating so formed, the addition of synthetic resins prolong the life of the film. This feature is attributed to the presence of a satisfactory filter which excludes the actinic rays of sunlight that would tend to deteriorate the film.

There are two types of synthetic resin used in lacquer formulation: hard and plastic. Hard resins exhibit such qualities as high melting point, hardness, rapid release of solvent, low viscosity in solution, high gloss, good durability and lend themselves to low ratio introduced to the nitrocellulose content. They require plasticiser additions. Plastic resins are very flexible and permit the use of a relatively high ratio of resin to nitrocellulose. They do not, however, act as plasticiser for the nitrocellulose; plasticiser must be added.

ESTER GUM

This manufactured resin has met with great favor and extensive use; especially in view of its great range of solubility and of a satisfactory price range. It is entirely soluble in all lacquer solvents without turbidity or precipitation. Ester gum imparts a high lustre to lacquers, but if used in too great proportions, will result in a brittle film. Solutions often enter as a portion of the pigment grinding vehicle.

Ester gum is prepared by the esterification of rosin (which is derived from the sap exudation of the pine tree) by the addition of glycerine. It is usually prepared in a closed kettle, which has bearing on the resultant color and acidity. The usual demand is for low acidity (acid number of 6 or less).

GLYCEROL PHTHALATE OR ALKYD RESINS

The name "Alkyd" is now accepted as a generic designation of the wide variety of resins formed by reacting a polyhydric alcohol, such as glycerine, with a polybasic acid such as phthalic, usually with

the addition of modifying agents such as fatty acids, oils or natural resins.

Raw Materials

Coal tar, which is obtained mostly as a by-product in the manufacture of coke, is the mother substance for many of the intermediates such as phthalic and maleic anhydrides used in the preparation of alkyd resins. When it is distilled, it is broken down to a long series of compounds ranging all the way from the highly volatile benzol and toluol to hard black pitch. Naphthalene, $C_{10}H_8$, an aromatic hydrocarbon, is secured from the middle portion of this complex distillate. By the action of oxygen in the presence of catalysts and the elimination of some water and carbon dioxide, it is converted into phthalic anhydride, which is the anhydride of an aromatic dibasic carboxylic acid.

Phthalic Anhydride

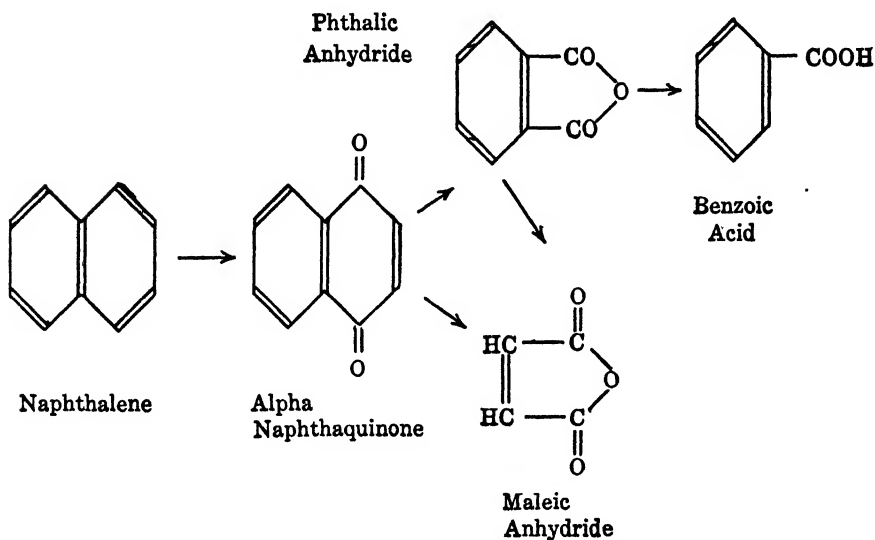
The actual conversion of naphthalene to phthalic anhydride, though superficially simple in principle, is really tremendously complicated to bring about in a safe manner, which will yield commercially feasible results. Uncontrolled catalytic oxidation, equivalent to complete combustion, of course, results in nothing but valueless CO_2 and H_2O . Even under the best of control, side products are unavoidable and some of them in modern practice are quite desirable. The formation of by-products naturally necessitates the development of procedures for eliminating and separating valuable constituents, in other words, modern methods for purification.

The kinetics of the reactions involved is charted in the major steps of the catalytic oxidation of naphthalene:

The problem has been how to add the oxygen to get the maximum yield of phthalic anhydride and to do it economically. Present day procedure is a radical departure from previous practice in that the naphthalene is now oxidized as a vapor with air in the presence of catalysts. Since the invention of the catalytic process a tremendous amount of work has been done to put it on the present basis of commercial efficiency. Much of this has been necessary to secure the exact control of temperature and other operating conditions and to develop

to the most efficient state the complex stabilized catalysts which are required.

The modern phthalic anhydride plant is a maze of stills, pumps, pipes, valves, compressors and dials, all automatically controlled and most of it under the watchful eye of a single operator. The naphthalene is melted as received and kept in warm storage so that it can be handled in liquid form. The first step is to pump it into stills where



it is vaporized. Then with the requisite amount of preheated air the naphthalene vapor is passed through the catalyst arranged in a multitude of tubes in the converter apparatus. A considerable amount of heat is produced in the reaction. The range of temperature within which good results are obtained is quite narrow. Therefore, very exact temperature control in all parts of the converter is essential. The most convenient method for control is the use of a bath surrounding the catalyst chamber in the converters, which bath preferably is subjected to forced circulation in order to maintain uniform temperatures and to dispose of excess heat produced in the catalytic reaction.

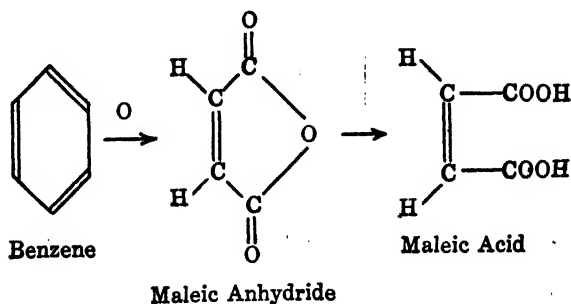
From the converters the hot vapors containing phthalic anhydride pass through a series of coolers and are condensed in large chambers.

This converter product is then subjected to purification by a series of operations, especially fractionated sublimation, whereby phthalic anhydride is collected in the form of long white needle crystals. As a commercial product offered in the market in large tonnage, it is of extraordinary purity, ranking in this respect with cane sugar. As it is rather bulky for packing in the form of needle crystals, it is also shipped in more compact forms, such as granules, made by breaking up the crystals, or the flakes, made by melting the needle crystals and chilling the liquefied phthalic anhydride on a drum flaker. Still another form known as grains is not only less bulky but freer from dust and may be poured out of the barrel more readily for the manufacture of alkyd resins and other products.

The largest and most rapidly expanding use of phthalic anhydride is now in the manufacture of alkyd resins. It is also used in the manufacture of dibutyl phthalate and related plasticisers — in pharmaceuticals, for instance, phenolphthalein, benzoic acid, etc., in the manufacture of dye intermediates, and dyes such as anthraquinone and its derivatives, phthalimid and its transformation products, eosin, etc.

Maleic Anhydride

Among the organic polycarboxylic acids used in the manufacture of alkyd resins, maleic anhydride ranks next to phthalic anhydride in importance, and its use is constantly growing in volume. It is



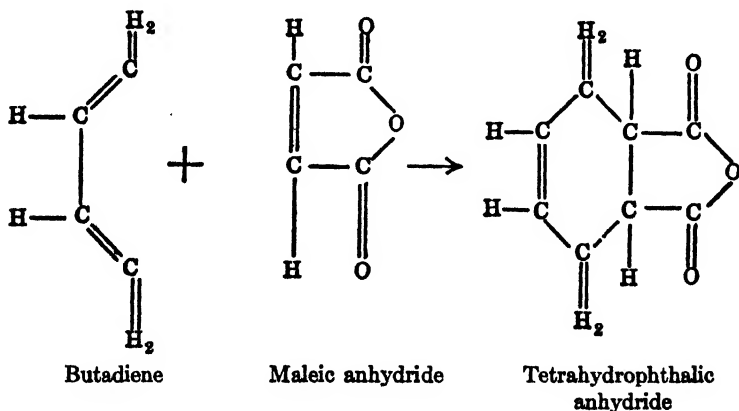
either formed as a very desirable by-product in the catalytic oxidation of naphthalene to phthalic anhydride or by the vapor phase catalytic oxidation of benzol.

The maleic anhydride is first obtained in the form of crude maleic

acid and is subjected to purification and recrystallization and then converted to the anhydride, which is the most preferred form for its use in the synthetic resin manufacture.

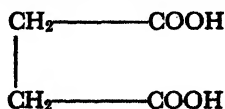
Maleic anhydride is extremely corrosive to metals in the presence of moisture and has in the vapor form a pronounced irritating effect on the eyes, nose and throat. It must, therefore, be handled with some care in the manufacture of synthetic resins and other products. Maleic anhydride forms colorless needle crystals melting at 53°C and, in the interest of convenience in handling, is generally sold in fused form. .

Maleic anhydride may be reacted like phthalic anhydride to form esters for resins and plasticisers. On account of its unsaturated character, it is frequently used together with such materials with which it condenses to form high molecular complex carboxylic acids, very useful acids for the manufacture of alkyd resins and related products. In this connection the so-called diene reaction may be mentioned as one by which such complex acids are formed. This reaction may be illustrated by the way that maleic anhydride adds itself to diolefins having conjugated double bonds to form new polycarboxylic acid anhydrides.



Succinic Acid

As can be seen from the structural formula:



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succinic acid is a reduction product of maleic acid, and is manufactured therefrom by either chemical, electrolytic, or catalytic reduction processes. Like phthalic anhydride and maleic anhydride, succinic anhydride is obtainable from the acid by subjecting it to heat treatment, but in order to avoid the many side reactions in this dehydration process, the acid is preferably used as such in industry. Since succinic acid was known as early as the sixteenth century to be the volatile compound obtained by the distillation of amber, it suggested itself as an acid for synthetic resin manufacture at an early date.

### **Polyhydric Alcohols**

When a monohydric alcohol, that is, one containing only one CH group, is combined with a polybasic acid, the result is a compound of definite chemical composition, such, for instance, as dibutyl phthalate, the most widely used plasticiser. To form the complex mixture of polyesters to secure a final product having resinous characteristics requires the use of alcohol having two or more OH groups. However, monohydric alcohol may be used in small proportions in conjunction with polyhydric types to modify the characteristics of a resin in definite respects. The polyhydric alcohol in most general commercial use for the manufacture of alkyd resins is glycerine which is a trihydric type obtained from fats and vegetable oils. Ethylene, diethylene, and other glycols synthesized from petroleum fractions are used to a lesser extent than glycerine, while a few other polyhydric alcohols find occasional use to impart specific qualities.

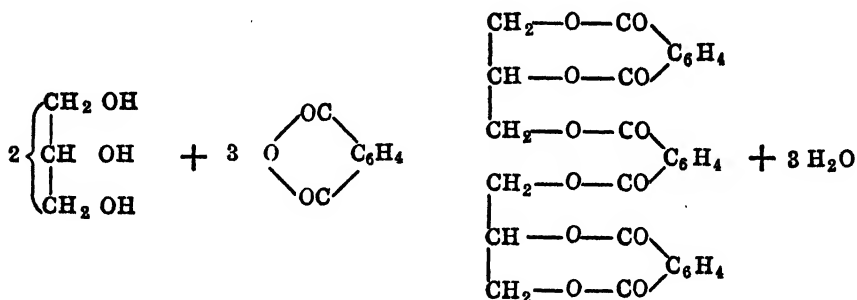
### **Modifying Agents**

Alkyd resins of the types suitable in surface coatings are generally modified by incorporating into their chemical structure some fatty acids. These, with the possible exception of stearic, are not used as single acids but as the mixtures naturally occurring in oils. Occasionally the oils are used as such in alkyd resin manufacturing, although it is more frequently desirable to first split them up into their components, that is glycerine and fatty acids, so that the structure of the resin can be built up as desired. Rosin, the chemical ingredient of which is abietic acid, is also used as a modifying agent in certain types of alkyd resins alone or in conjunction with fatty acids. Occasionally other natural resin acids find similar use. Syn-

thetic resins of various types, particularly phenol condensates, are frequently incorporated into alkyd resins to modify them in certain characteristics.

### Resin Formation

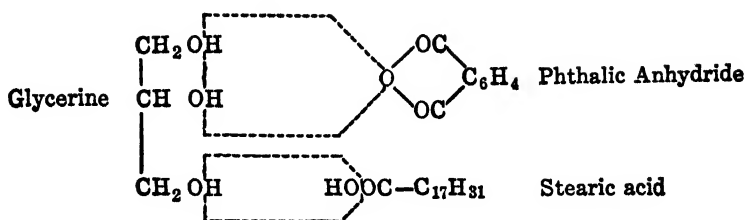
The theoretical reaction between glycerine and phthalic anhydride, considered as a simple esterification, may be presented by the following equation:



Actually, however, the formation of a resin from these materials is accomplished by a variety of reactions of a much more complex character, resulting in a multiplicity of complex polyesters formed mostly as closed ring groups by cross linkages, and having a wide range of molecular weights. When the materials are reacted, even at temperatures as low as 160°C, about half the theoretical esterification occurs in the first few minutes after which it proceeds very slowly with gelation invariably occurring before esterification is complete.

When ethylene glycol is substituted for glycerine, and succinic acid for phthalic, the reaction results in the formation of long open chain polymers which may carry either hydroxyl or carboxyl groups at the end. Such resins are less readily polymerized by heat and exhibit greater flexibility than the phthalic glyceride type. Still other variations are secured through the use of other polybasic acids such as edipic, sebasic or maleic, or other polyhydric alcohols such as diethylene glycol.

If the phthalic or other polybasic acid is replaced in part by fatty or natural resin acid, the resultant product may be visualized by the following:



Such products are known as “modified” alkyd resins and include practically all the alkyd resins used in lacquers and other surface coatings. Since for these products a large variety of polybasic acids, polyhydric alcohols and modifying acids are available, and since they can be combined in various proportions and under different conditions, it is readily apparent that an infinite number of such resins can be made.

### Resin Manufacturing

The manufacture of alkyd resins is analogous to the manufacture of varnish in that it involves processing over a similar range of time and temperature with the resultant products somewhat alike in many of their physical attributes. There is at any rate a sufficient degree of similarity so that much of the early manufacture of alkyd resins was carried out in equipment differing very little from that used for the manufacture of varnish. The kettles were portable types, with loose fitting covers and a capacity of about one to two hundred gallons. They were heated over the ordinary type of open fires and finished resin made into solution by thinning and clarifying according to ordinary varnish manufacturing procedure. It was soon found that in order to secure resins of extremely pale color, maintain soluble uniformity of chemical and physical characteristics, and meet the demand for tremendous volume of these resins, equipment of an entirely different type would be required.

In a modern alkyd resin manufacturing plant the kettles are designed for cooking batches of several tons at a time. They are built of special alloys, carefully selected to avoid corrosion and consequent discoloration of the resin. Gas, oil, or electricity may be used for heating so long as it is applied in a manner which provides for uni-

form distribution and exact control. The so-called kettle is in reality a still, tightly closed to permit retention or removal of the products of reaction at will through the use of pressure, vacuum, reflux condensation, or otherwise. Intricate supplementary equipment is necessary for complete processing. Even the simple task of temperature control has grown from the familiar varnish maker's thermometer to a complex automatic system of thermocouples, radio tubes, and recording indicators. Only by such means can the complicated reactions involved in resin formation be kept so in hand that the resultant product is duplicated exactly in successive batches.

Many natural and synthetic resins are hard and friable and can readily be broken up to small lumps for use by the varnish maker or other consumers. Some alkyd resins can be handled in a similar manner, particularly the rosin modified types in Group 3. Most of those in the other groups are, however, sticky plastic solids at ordinary temperatures. Therefore, except when they are to be given a further cooking by the customer, they are most conveniently shipped and used in the form of concentrated solutions in suitable solvents. Hence on completion of the cooking process, these resins, instead of being run into trays or packages for cooling in the solid form, are mixed with the solvent in a secondary processing kettle. The finished solution is then filtered or clarified, thus providing the consumer with a much cleaner product than is feasible in the case of resins which are shipped in the solid form.

### Classification

Commercial varieties of alkyd resins range from the friable solids to viscous liquids. For convenience in studying their general characteristics, they may be classified according to their composition and suitability for various uses into five main groups, the members of which have similar characteristics. These groups are as follows:

- (1) Unmodified compounds of polybasic acid and polyhydric alcohol.
- (2) Alkyd resins in which the modifying agent is mostly saturated fatty acid.
- (3) Alkyd resins modified principally with natural resin acids.

- (4) Alkyd resins in which the modifying agent is largely unsaturated fatty acid.
- (5) Combinations of alkyd resins with resins of other types such as phenol formaldehyde condensates.

GROUP 1 — The main use of these unmodified condensation products of polybasic acids and polyhydric alcohols is in bonding, insulation and molding. Their use in surface coatings is limited to such specialties as cellulose acetate lacquers and water paints. Phthalic glyceride, when sufficiently reacted to form a hard resin, is soluble in ketone, ester and alcohol solvents but not in hydrocarbons, and it is not very compatible with the ordinary ingredients of lacquer or varnish. It is hygroscopic and readily affected by long contact with water. It is converted by prolonged heat treatment to an infusible and insoluble resin.

GROUP 2 — The replacement of dammar and ester gum by the alkyd resins in this group, that is, those modified principally with saturated acids, has practically revolutionized the lacquer industry. These alkyd resins are superior to resins of other types in adhesion, toughness, and resistance to oils and alcohol. Their most notable characteristic is, however, that when combined with nitrocellulose and plasticisers they produce lacquers of exceptional durability on exposure to the weather. This permits the formation of pigmented lacquers of greatly improved gloss and color retention. It also makes feasible the production of clear lacquers which, while not as durable as the pigmented variety, are at least much more durable than any clear nitrocellulose lacquer which could previously be made. The outdoor durability of such lacquers is increased as the proportion of alkyd resin to nitrocellulose is increased, the limiting factor from a practical standpoint being the reduction in film hardness as the proportion of nitrocellulose is decreased.

The commercially available alkyd resins in this group range from hard friable solids to viscous liquids. In most of them the proportion of modifying fatty acids is relatively low, about 30%, the balance being phthalic glyceride or a similar compound. Generally speaking, they are compatible with nitrocellulose in all proportions, while a few of them have also a limited compatibility with cellulose acetate. They are also compatible with most of the plasticisers and other

resins ordinarily used in lacquer formulation. Most of them are completely soluble in coal tar hydrocarbons and permit a rather limited dilution with petroleum solvents. They are freely soluble in ketones, esters and some chlorinated solvents. No special precautions are required in the storage of these resins either in solid or solution form as they oxidize and polymerize very slowly.

One of the large uses of these resins is in pigmented auto body lacquers, both in solid colors and in iridescent finishes. They are also used in clear outdoor lacquers, both over colors as on signs and similar applications, and for the protection of polished metal. They are important ingredients in clear and pigmented furniture lacquer primers, and are also used to some extent in special printing inks.

GROUP 3 — These alkyd resins, modified principally with abietic or other natural resin acids, find extensive application in both varnish and lacquer for indoor use. They lack the toughness and extreme outdoor durability of alkyd resins modified entirely with fatty acids. Solutions of these resins applied as thin films tend to release the solvent more rapidly than other resins of comparable hardness. This results in rapid setting and hardening of the film, which is advantageous not only in lacquers and varnishes, but also in printing inks and other products.

When used in nitrocellulose lacquers, these resins impart gloss, hardness, sanding and rubbing qualities, which make them especially useful in clear and pigmented furniture lacquers and in lacquer sanding sealers. On account of their ready solubility in ordinary lacquer solvent mixtures, they produce solutions of low viscosity and since their hardness permits the use of high proportions of resin to nitrocellulose, they permit the formation of lacquers of high solid content at working consistencies.

When cooked into varnish, especially short oil types, the alkyd resins in this group impart high gloss, pale color, and resistance to discoloration on baking or aging. Hence varnishes made from them are particularly useful as enamel vehicles for white and pastel tints. Their hardness and easy rubbing qualities make them useful in furniture rubbing varnishes.

GROUP 4 — These alkyd resins, modified with unsaturated fatty acids, differ from the three groups previously discussed, as well as

from resins of most other types, in that when exposed to the air in thin layers, they dry to hard solid films. They may, therefore, be used alone to form durable distensible films without cooking with oil or combining with nitrocellulose. In other words, they differ from other types of natural and manufactured resins in combining in themselves qualities of gloss and hardness, usually associated with resins, together with the elasticity and toughness ordinarily secured by combining resins with drying oils. The alkyd resins in this oxidizing group cover a wide range of hardness, flexibility, and other characteristics. They impart exceptional durability on exposure to the weather, which is especially evident by prolonged retention of gloss and color. They have, in addition, excellent adhesion and retention of elasticity with age. They do not discolor as readily as ordinary oleoresinous varnishes on baking or on prolonged exposure to light, and are therefore used to advantage as vehicles for white and pastel tint enamels.

The solubility of the resins in this group varies considerably, depending upon the kind and proportion of modifying agents, the degree of polymerization, and other factors. Some of them have only a limited solubility in aromatic hydrocarbons and require the addition of ketone, alcohol or ester solvents to produce solutions of low viscosity. Some of them are completely soluble in mineral spirits and readily miscible with oils and varnishes. The majority lie between these two extremes, are usually dissolved in a mixture of mineral spirits and coal tar naphtha, and have a limited miscibility with some oils and varnishes.

The drying of films of these resins is accelerated by the addition of small amounts of certain metals, particularly lead and cobalt, although others such as manganese, iron, and zinc are also used. These driers are added cold to the resin in the form of solutions of metallic soaps. Combinations are usually more efficient in drying effect than single metals. The exact amount of metal required depends on the pigment and other materials with which the resin is combined, as well as the particular conditions of application of the finished product.

The resins in this group are widely used as the vehicles for air-drying enamels for trucks, signs, lawn furniture, filling station equip-



ment, and similar applications requiring a combination of quick drying and outdoor durability. Similar enamels are baked on auto bodies, bicycles, toys, refrigerators, and a wide variety of other articles. In addition to outdoor durability, their value lies in their exceptional color retention, adhesion, and toughness, and in the speed of finishing made possible by the baking of several coats in one operation. They are used in machinery enamels to resist heat and oil, and in architectural enamels for drying speed and color retention. They find some use in the replacement of a portion of the linseed oil in the conventional types of ready mixed house paints to secure improved gloss and color retention on prolonged weather exposure. Their use in this direction is limited to some extent by cost and brushing difficulties. When these resins are cooked into varnish, the resultant product represents a compromise between the characteristics of the oxidizing alkyd resin and ordinary oleoresinous products. Such varnishes are finding increasing use in tinware coating and as the vehicle for pigmented enamels and undercoats for a variety of applications. The oxidizing resins also find some use in nitrocellulose lacquers, especially for outdoor use. They impart some tendency toward lifting on recoating which makes their use most feasible in one coat applications, such as clear finishes for signs and hardware.

GROUP 5 — Alkyd resins in any of the groups previously described may be modified by combination with resins of other types. Generally speaking, the result is a compromise on the qualities of the different resins in about the proportion in which they are combined. From a commercial angle, the most important resins in this group are combinations of phenol resins with the oxidizing type alkyd resins in Group 4. Such modifications with phenol condensates generally tend to slow down the initial drying, but improve final hardness and water resistance with some sacrifice of gloss and color retention on prolonged exposure to the weather.

These phenol modified alkyd resins find extensive use in colored air drying and baking enamels along much the same lines as the oxidizing type alkyd resins in Group 4, just described. They are also of special interest in undercoats, such as the primer-surfacers baked on auto bodies as well as in similar products which are air-dried.

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## Summary

The alkyd resins occupy a unique place in the coating field due to their versatility. They may be used in lacquers, blended with oils and varnishes and baked or air dried by themselves, depending on the manner in which they have been modified. The oxidizing types may be air dried or baked; being both oxidizable and heat convertible. The alkyd resins are the most durable resins obtainable for outside exposure and the gloss retention properties are excellent. Although not entirely resistant to water when films are submerged, the resistance to the elements on outside durability tests is phenomenal. Alkyd resins modified with rosin, non-drying oils or small amounts of drying oils are especially recommended for lacquer formulation. The property of holding out successive coats of lacquers, the high solid content permissible, and the depth and lustre of the films obtained, go far in establishing their general use in lacquers. Alkyd resins impart toughness and hardness and, due to their plasticising action, some allowance should be made when incorporating oil or chemical plasticisers in lacquer formulae. The resistance to ultraviolet light is an important property and the decomposition of nitrocellulose will be appreciably retarded by the addition of these resins.

Alkyd resins are thermoplastic and this property has been recognized in producing high gloss lacquers free from orange peel without the necessity of rubbing. Lacquer films maintaining a high ratio of resin to nitrocellulose are subjected to low bake or force dry, then are sanded to remove high spots in the orange peel and subjected to a second bake of slightly higher temperature. The resulting film is a high gloss and gives the appearance of great depth. Due to the slight "sweating" of the alkyd resins, additions of small percentages of hard natural or phenol formaldehyde resins will reduce the tendency to be tacky.

## Baking

The harder oxidizable and semioxidizable types of alkyd resins are essentially for baking purposes, requiring temperatures of 250°F–325°F to acquire conversion to the insoluble state, where they are resistant to many solvents, including alcohol. The slightly softer oxidizing resins may be baked at lower temperatures, and excessive

temperatures should be avoided or wrinkling and darkening may ensue.

At temperatures of 225°F–275°F, the baking is due mostly to oxidation. The soft oxidizable resins are essentially air-drying resins, but may be force dried at temperatures of 180°F–225°F. When baking alkyd resins, driers are not ordinarily used. Small percentages of cobalt-zinc naphthenate (1–3) are generally recommended where schedules do not permit long baking periods or where pigments (e.g., reds and blacks) have a tendency to lengthen the baking period over that normally required.

### Air Drying

The hard oxidizable types of alkyd resins are used for fast (set-up) coatings due to their initial hardness and solvent retention. Their success in application is determined by applying in thin coats, and it may be stated that the oxidation period of this class of coatings is not decidedly shorter than that of the softer type, due to the fact that the modified drying oils in each require a definite interval to oxidize. The slightly softer oxidizable types enjoy the property of “setting up” fast and becoming dry in a relatively short period of time. The soft oxidizable types are similar to oil varnishes as regards drying in that they “set up” more slowly and dry more slowly to a hard film.

### Solvents

The solvents required for alkyd resins vary from toluol, xylol, etc.; to V.M.P. naphtha and mineral spirits. The harder types require the aromatic solvents and the softer types require the hydrocarbons or petroleum solvents for best results. The intermediate types as regards hardness, usually require mixtures of both aromatic and hydrocarbon solvents in order to insure stability. It is interesting to note that a few per cent of butanol (e.g., 5%) will cause a marked decrease in the viscosity when added to a formula employing a hard type alkyd resin. Although not a solvent for alkyd resins, it is believed that butanol assists the dispersion of the resins in solvents by being absorbed in the gel-like structure where it influences its polar properties. With regard to solvents when alkyd resins are employed in lacquers,

the usual solvents are generally permissible. However, the use of ethyl alcohol should be avoided in concentrations greater than that introduced by the wet nitrocellulose, and petroleum diluents should only be used in small quantities; toluol is the customary diluent.

### **Driers**

Driers of the naphthenate type have been found to be more desirable in connection with alkyd resins. The kind and amount of driers to use depends somewhat on the formulation and its intended use. Generally speaking, however, a tri-metallic drier consisting of cobalt, manganese and lead, is found more efficient for air drying while cobalt-zinc (1-3) works to best advantage in the instance of baking enamels.

### **Compatibility**

The softer types of alkyd resins are usually compatible with oils and varnishes; the manufacturers usually indicate those resins embodying this property. It must be realized, however, that blending with oils makes for ease of brushing at the expense of durability. Compatibility with zinc oxide and other basic pigments is usually determined by the acid number of the solid resin. As a general rule, a resin vehicle with an acid number below 15 (based on the solids) can be used with basic pigments without undue bodying action. It may be stated that the acid number of alkyd resins has little, if any, bearing on the durability of these products. Alkyd resins are completely compatible with nitrocellulose and due allowance should be made for their plasticising action when incorporating oil or chemical plasticisers.

### **Lacquer Types**

The use of rosin in modifying alkyd resins gives a resin of properties somewhat similar to ester gum, but with increased durability and resistance to rubbing oils. Its use is particularly recommended in wood lacquer formulations. Resins of the semi-oxidizable type are recommended for exterior lacquers in view of their great durability. Using white pigments which are known to be comparatively non-yellowing, lacquers embodying alkyd resins approach the ideal non-yellowing durable finish.

### **Amberols**

These hard resins can be classified as rosin-modified alkyd resins. They are products of the Resinous Products and Chemical Company and are designated:

Amberol No. 800 — No. 801

Amberlac D-96 — B-94

### **Paraplex Resins**

These resins, designated as RG 2, RG 7, 5 B and G 20 are in the general alkyd class. They are of a rubber-like character and when used in nitrocellulose films should be employed with resins as indicated in the Amberol or "hard resin" class. They are products of Resinous Products and Chemical Company.

### **Duraplex**

This class of resin belongs to the alkyd group, being modified with drying and non-drying oils, designation C-51 being of the drying type while ND-75 is of the non-drying type. Products of Resinous Products and Chemical Company.

### **Beckosols**

Alkyd resin solutions supplied under this brand are products of Reichhold Chemicals. There are five general types:

- (1) Drying pure alkyds, No. 1307
- (2) Non-drying pure alkyds, No. 1308
- (3) Phenol modified alkyds, No. 1320
- (4) Oil and phenol modified alkyds, No. 1
- (5) Non-phenolic alkyds, No. 1319

### **Rezyl Resins**

The oxidizing type of alkyd resins is modified principally with drying type fatty acids or oils. This type may be formulated into paints, varnishes, and enamels by properly compounding them with the necessary driers, solvents, pigments, and oils. They are manufac-

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tured by American Cyanamid and Chemical Corporation. Outstanding products and recommended uses are:

Rezyl 330-5 and 420-5 — Non-yellowing enamels and clear finishes.

Rezyl 775-1, 113, 114, 1102 — Quick drying enamels and clear finishes.

Rezyl 869-1, 110, 1103 — Brushing enamels and paints.

The lacquer type rezyl resins are those modified principally with saturated fatty acids and may be of the oxidizing or non-oxidizing types. Resins of these types, when added to a nitrocellulose lacquer are not only tough but actually impart markedly improved outdoor durability. Recommendations are:

Rezyls Nos. 12, 14, 19, 22, 53, 99-4 and X-315

### **Teglac Resins**

Teglac resins are the alkyd types which have been modified principally with natural resin acids. Teglacs possess hardness, gloss, good sanding qualities, and resistance to rubbing oils and alcohols. They have a wide field of application in nitrocellulose lacquers, but are suggested particularly for lacquer sealers. They are restricted for use indoors. This group is represented by: Teglacs No. 15, Z-152 and Z-154 and are products of American Cyanamid and Chemical Corporation.

### **Urea-Formaldehyde Resins**

These water-white resins of the heat-hardening (thermo-setting) types are finding ready application in industrial enamels, particularly in the refrigerator industry. They are primarily intended for baking applications (200°F-350°F) and may be blended with alkyd resins to obtain exact films. Urea resins may be used with nitrocellulose where such films are subjected to heat treatments.

### **Vinylite Resins**

These thermo-plastic resins are "flexible" and are used in the formation of many crystal clear molded products. The copolymerized vinyl chloride and vinyl acetate types of this series of resins are employed in the formation of protective lacquer coatings for

metal sheets and protective linings for beer cans. A very excellent paper entitled, "'Vinylite' for can and container coatings" was recently presented at the Franklin Institute (9A) and should be read by those interested.

### Polystyrene Resins

These resins find a great field of usefulness in the molded plastic industry and possess excellent electrical properties. Polystyrene resins are water white in color and when made into protective or decorative coatings are alcohol and water resistant. When made into enamels for use on metal refrigerators, it is of particular interest that these coatings do not become brittle at temperatures as low as  $-30^{\circ}\text{C}$ .

### Melamine Resins

Synthetic resins produced from Melamine and in combination with modifying agents possess outstanding characteristics, some of which are not found in other types of thermosetting resinous compounds. Of particular interest is a combination of gloss and color retention when the enamel is subjected to high temperatures for prolonged periods. This improvement in film characteristics of baking enamels is of particular interest to manufacturers of refrigerators, electric appliances and stove parts where high heat resistance is necessary.

Melamine resin enamels cure quickly at temperature ranges of  $180^{\circ}\text{F}$  to  $220^{\circ}\text{F}$  and produce exceptionally hard films, which possess water, alkali, solvent, and grease resistance; a fact which is unusual in non-yellowing finishes. Melamine resins may be used in combination with nitrocellulose lacquers. They are a product of the American Cyanamid and Chemical Corporation.

### REFERENCES

Certain information on alkyd resins was supplied through the courtesy of Mr. J. McE. Sanderson, American Cyanamid and Chemical Corporation.

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(8) Reinhold Publishing Corporation, 1937.

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## PIGMENTS

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The manufacture and use of "colors" is one of the oldest known arts. Biblical references are made to the use of pigment matter and early documents refer to color and its use as exemplified by wall pictures in colors. As a matter of fact, colored coatings as a covering for structures date back to remote antiquity.

Color is present with every object that we see. It is a decoration provided by nature; no matter where we turn, God's green earth is alive with color.

### Color Vision

Color is a quality of visual sensation resulting from light action on the nerve centers of the eye. To produce this sensation, light is necessary. A substance having the faculty of breaking the light into its spectrum is also necessary. This substance reflects and absorbs the light of different colors. A rainbow following a summer's rain is caused by water particles in the atmosphere which break up the sunlight into its constituent colors. The different colors of which a given light is composed, arranged in the order of their wave length, constitutes the spectrum of that light. The rainbow is the spectrum of sunlight. All light from glowing solid bodies has a continuous spectrum; that is, there are no blank spaces between the different colors. Red is the longest wave length and violet the shortest, the other colors following in accordance with their length.

Without light there can be no color. A casual glance at a given



colored surface, and a quick reply as to that color, indicates that what is seen is a substance which light is striking and has the faculty of absorbing all colors but that particular color of the spectrum. This color is reflected light giving the sensation of color to the eye. Color, as a general term, is referred to as any kind of light sensation other than black and white. Black reflects very little light, most of the light striking such a surface being absorbed.

The word color is used in three different senses: The color of light, which depends upon the relative power of the different wave lengths which the light contains. The color of a surface, which depends upon its reflectivity for the different wave lengths. The color seen, which depends upon the kind of sensation produced in the visual centers in the brain.

The three distinguishable color qualities are hue, value, and chroma. Hue is the quality which distinguishes a red from a yellow, a green or a blue. Value is the quality which distinguishes a light color from a dark one, i.e., white from black. Chroma is the quality which distinguishes a strong color from a weak one.

Consideration of color are matters of judgment or opinion, upon which individuals will disagree. The subject of color constitutes a very large and complicated field of study and one in which there are endless differences of opinion and theory. Great strides in chemistry, culminating in recent developments of colors from coal tar, have furnished tremendous impetus to the lacquer and synthetic enamel industries.

Such instruments as Munsell Universal Photometer, Pfund Multiple Reflection Colorimeter, General Electric Spectrophotometer, cryptometer, nigrometer, etc., are used to advantage in the pigment and lacquer industries as a means of color evaluation and for color matching purposes. Their uses are described under the subject of TESTS, Chapter IX.

So far as practical color mixing is concerned, red, yellow, and blue are the primary colors and the combination of two or all three of these in various proportions, plus black or white, will sometimes theoretically give any shade desired. The reason it is not possible to carry out this theory in practice is because there are no red, yellow, or blue pigments that are true spectrum colors;

that is to say, every pigment color available is really a combination of at least two spectrum colors — every red contains an element of blue or yellow, every blue an element of red or yellow, and every yellow an element of red or blue. Light para red, for instance, is “yellow” against a deep para red, which is “blue” in comparison, and therefore when either shade is used in color mixing, not only is red introduced into the mixture, but “yellow” or “blue” as the case may be. The most important thing to remember in color mixing is that the introduction of a complementary color always results in a loss of brilliancy; in other words, the mixture tends toward black or total absorption.

### Colors for Lacquers

Because of the fact that clear nitrocellulose films are disintegrated by light, pigments employed in lacquers not only serve to give the desired color effect, but what is equally important, they retard the breaking down of the lacquer film by ultraviolet light. It is highly desirable therefore to use only the strongest colors in the manufacture of lacquers, because by so doing the minimum amount of pigment can be introduced and still sufficient opacity obtained, where opacity is desired.

The ideal color for lacquer is one chemically inert, possessing very good permanency, low oil absorption, soft texture, great tinctorial strength, and good hiding power. Unfortunately it is not always possible to secure a color of a given shade which will have all of these qualities, and it, therefore, follows that at times certain of these characteristics must be sacrificed in order to secure other attributes which are more important for the work in hand.

In evaluating colors, the chemical composition is usually not nearly as significant as physical characteristics; and physical tests are, therefore, commonly employed rather than extensive quantitative analysis.

### Testing for Shade and Strength

In testing for mass tone (which is the pure color made into a paste by mulling with a suitable vehicle), it is absolutely essential, if dependable comparisons are to be made, that exactly the same

amounts of pigment and vehicle be used in mulling the two colors to be compared, and exactly the same amount of mulling be given each sample. Any variations in proportion of pigment to vehicle, or variations in the amount of mulling, will cause marked differences in the results secured. One gram of a low oil absorption pigment or one-half gram of a high oil absorption pigment is all that should be mulled. Raw or refined linseed oil is a satisfactory vehicle. The amount to use depends, of course, upon the oil absorption, but only a sufficient quantity should be employed to make a paste of fairly stiff consistency. The amount of mulling should be predicated upon the degree of dispersion the pigment would normally receive, and this, of course, depends upon the texture of the pigment, the value of the pigment, etc. Soft pigments, such as titanium dioxide, zinc oxide, lithopone, chrome yellows, reduced greens, etc., should be rubbed 50 times. Stronger pigments, such as C.P. light and medium greens, should be mulled 100 to 150 times; C.P. deep greens 200 times; C.P. iron blues, carbon black and certain of the reds 300 times, with a pick-up after each 25 or 50 mulls. The mulling should be done on a surface with a fine "tooth," such as a piece of sand-blasted plate glass, with a muller having about a 2½ inch face, and each mull should traverse a space of about 3 to 4 inches wide and 12 to 15 inches long. It is essential that the same even pressure and length of stroke be given the sample as well as the standard. After mulling, the two paste colors should be placed on a slide in juxtaposition, drawn off with a putty knife and the comparison noted immediately. Color comparisons should not be viewed through the glass, as this is misleading, because color comparisons are affected by the continuity of the line of reflection.

In making strength tests, 20 : 1 tints are about the right strength on the weaker colors, such as chrome yellows or chrome greens, while 50 : 1 tints should be made on the stronger colors, such as iron blues, carbon blacks, the paras, toluidine, lithol, and phosphotungstic toners. In making strength tests, the simplest and most accurate way is to take the required amount of paste colors which has previously been rubbed for the mass tone comparisons (100 mg. in the case of the 20 : 1 tint) and combine it with 2 g. of previously ground paste white, made either from zinc oxide or litho-

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pone, simply mixing the two pastes with a spatula until streaking has been eliminated.

Only the strongest colors of a given "family" should be employed in lacquers. Other factors being equal, the stronger the color the greater its permanency, and the better the hiding power, therefore, the fewer ounces per gallon required to secure the same opacity, consequently the lower the pigment content by weight in the finished lacquer, which improves the gloss and simplifies the dispersion problem in exactly the same way as does low oil absorption. Many people believe because a color is designated as C.P. or called a "toner" that this is prima facie evidence that the color is the strongest of its type obtainable. This is far from being correct. There are tremendous differences in the various C.P. colors and toners offered by different manufacturers and it is only by a careful strength determination that a color can be accurately evaluated. An accurate strength determination cannot be made by taking the dry color and zinc oxide, adding oil and rubbing in a haphazard fashion. The same procedure should be followed as has been found expedient in actual factory operation, that is to say, the color should be rubbed separately and the paste color then combined with zinc oxide. Other factors being equal, strength is the true measure of value, not price per pound. It costs no more to grind a pound of a strong C.P. color properly than it does a pound of weak C.P. color; the strong one will hide more per square feet per pound when used as a solid color, or will tint more gallons per pound when used with white, consequently the strongest colors are always the most economical to use from a cost standpoint, and at the same time produce lacquers of the best quality.

### Permanency of Color

The permanency of a given color is difficult to define or express in a definite way, because it is so variable, affected as it may be by a great many different factors. A color may give satisfactory service, so far as permanency is concerned, when used in one way, and be absolutely unsatisfactory when employed in a different way. A color which is permanent when used alone is sometimes not as permanent when mixed with a large proportion of a white

opaque pigment, such as zinc oxide or lithopone, and is always not as permanent when an inert extender is used, such as barytes or clay. It is easy to reason out why the permanency of a color is affected when it has been extended with an inert, such as barytes, because of the change in refractive index, which takes place as the film disintegrates, but why a combination of a permanent white pigment, such as zinc oxide or titanox, with some relatively permanent pigment colors should be less permanent in combination than alone is still not understood.

Any change which takes place in a color on exposure is usually called fading, but strictly speaking, true fading is that color change which results from the destruction of color by light. Many of the color changes observed, however, do not result from this cause at all. For example, in the manufacture of chrome green paints, it is common practice (because chrome green has such good hiding) to use only 15 to 25 per cent of pure green, the balance of the pigment content being extender, such as barytes or clay. When such a paint is exposed, there is a marked change, as it weathers, in the refractive index relationship between the extender and the disintegrated vehicle, with the result that the paint after exposure shows a "faded" or chalky effect. However, if such a painted surface is again coated with oil or varnish, it will be found that the color is restored, proving very conclusively that the chrome green itself has not faded. Red lead or orange mineral paints, after a short exposure, appear to turn white, but this apparent change in shade is nothing but a thin film of lead carbonate that forms on the surface. Sometimes, too, paints made from chrome greens and other pigments sensitive to alkali come in contact with drippings from freshly made concrete, which results in the decomposition of the blue portion of the green, causing a change in shade without sunlight having played any part at all.

On inorganic colors, such as chrome greens and chrome yellows, the only accelerated test for light fastness that can be made is to measure the degree of darkening by exposing either an enamel or a drawout to the carbon arc for 20 to 30 hours. A drawout is made by rubbing the color in heat-bodied oil and pulling it down thin with a putty knife on paper. On inorganic pigments dependable accel-

erated tests can be made in a short period of time by reducing the organic pigment to about 10% strength with aluminum hydrate, then making a drawout and exposing the two reduced colors simultaneously in juxtaposition on the same piece of paper. The mercury arc is not dependable for colors, because it does not always give results consistent with sunlight.

Keeping in mind that permanency is relative and is effected by many factors, possibly the following numerical permanency rating of some red pigments may serve as a guide, though they must not be taken too literally and no pigment rated below 90% should be used where permanency is a factor without an exposure test being made before the color goes into production under the conditions that will prevail in actual use:

|                                              |      |
|----------------------------------------------|------|
| * Strong madder lake .....                   | 100% |
| Toluidine toner .....                        | 100% |
| Para toners .....                            | 90%  |
| Lithol rubine toners .....                   | 85%  |
| Rhodamine toner, tungstic precipitated ..... | 75%  |
| Lithol toners .....                          | 70%  |
| Red for lake C toners .....                  | 60%  |
| Alphanaphthylamine .....                     | 50%  |
| Scarlet lake .....                           | 40%  |
| Bordeaux lake, concentrated .....            | 30%  |
| Rhodamine toner, tannic acid ppt. ....       | 15%  |
| Eosine toner .....                           | 10%  |

## Oil Absorption

One of the primary problems in lacquer formulation is to secure as high a percentage of film forming material as possible. Great progress has been made along this line, and inasmuch as the film forming material in the clear lacquer base acts as the cementing medium which causes the color particles to adhere to the surface to which the lacquer is applied, it is obvious that the ideal lacquer color is one of low oil absorption, thus requiring a minimum amount of binding material to firmly cement the color particles to the surface to which it is applied. Low oil absorption also tends to simplify the grinding problem, because of the small amount of grinding liquid required to make a paste of the proper consistency for grinding if a

stone or roller mill is employed, or if the grinding vehicle employed is of such a nature that only a limited amount can be introduced into the lacquer. The gloss of the finished lacquer will be better, too, since gloss simply indicates continuity of surface and as a low absorption pigment has less specific surface per unit of weight, it follows that the interstices between the pigment particles in the film will be filled more uniformly and the particles themselves will be covered to a greater depth — both of which will tend to produce continuity of the lacquer film; hence, a better reflective surface and consequently higher gloss. Some "families" of pigment colors possess relatively high oil absorption and it is not possible to lower the oil absorption of these pigments without changing other characteristics and altering the color to such an extent that it would virtually be an entirely different product. Because different grinding mediums have different wetting properties, and because the same types of color made by different manufacturers vary in oil absorption, it is difficult to give exact figures as to the amount of vehicle which will be required for grinding a given color, but the following data, indicating the amount of raw linseed oil required to grind various colors to pastes of about the same consistency, may be of some assistance:

|                                       | <i>Pounds of<br/>dry pigment</i> | <i>Pounds of raw<br/>linseed oil</i> |
|---------------------------------------|----------------------------------|--------------------------------------|
| Extra strong madder lake .....        | 100                              | 160                                  |
| "High color" carbon black .....       | 100                              | 155                                  |
| C.P. deep para toner .....            | 100                              | 150                                  |
| C.P. light para toner .....           | 100                              | 140                                  |
| C.P. non-bronzing prussian blue ..... | 100                              | 140                                  |
| C.P. lithol toner .....               | 100                              | 120                                  |
| C.P. toluidine toner .....            | 100                              | 100                                  |
| C.P. non-bronzing chinese blue .....  | 100                              | 80                                   |
| C.P. medium chrome green .....        | 100                              | 50                                   |
| C.P. medium chrome yellow .....       | 100                              | 35                                   |
| Titanium dioxide .....                | 100                              | 20                                   |

Oil absorption refers to the minimum amount of oil required to just wet a unit weight of pigment completely. Raw linseed oil is generally the wetting medium employed.

The question of oil absorption is important in lacquer formulation only if the color is dispersed on stone or roller mills.

## Bleeding

The bleeding of colors is an important test and may be carried out in the following manner: 1 g. of dry color may be placed in 100 cc. of solvent, soaked for 24 hours with occasional shaking, then filtered and observe whether the filtrate is stained or not. The color may also be striped with white to determine its bleeding.

## Identifying Pigments

In identifying pigments of unknown composition, certain deductions can be drawn from the shade and strength of the color under examination, and comparing the reaction of the dry powder in hydrochloric and sulphuric acids and strong caustic in a porcelain color comparison plate will help further to identify the pigment, also testing it for bleeding in various solvents. In this connection the following data may be helpful:

**BLUE PIGMENTS** — Iron blue is very sensitive to caustic. Ultramarine blue is decolorized by hydrochloric acid and an  $H_2S$  odor is evolved. If the color is a blue lake made from a basic dyestuff, it will bleed in alcohol.

**GREEN PIGMENTS** — Chrome greens are sensitive to caustic. Chromium oxide is totally lacking in brilliancy as compared with chrome green, and is not affected by any acid or alkali. Organic greens made from basic dyes will bleed in alcohol. Ammonia develops a blue stain, if applied to Paris Green. Hydrated chromium oxide is non-bleeding in all solvents, is unaffected by any acid or alkali, and possesses unusual light fastness.

**YELLOW PIGMENTS** — Sodium sulphide solutions blacken lead chromate yellows. If the test is applied to an enamel or paint, the reaction may be misleading as lead may be present in a drier in the case of zinc or cadmium yellow. Cadmium yellow is decomposed by concentrated hydrochloric acid. Hansa yellows bleed in chloroform. Zinc yellow is practically soluble in acetic acid.

**RED PIGMENTS** — Identifying the different organic reds is more involved than the identifying of other colors, because there are so many of them and very often mixtures are encountered. A good deal, however, can be deduced from the shade, as different reds are quite distinctive in this respect to those familiar with colors. Lithols



have a much cleaner tint than para or toluidine and are insoluble in chloroform, while toluidine and para reds are soluble. A study of the light resistance, after a few hours' exposure to the carbon arc, is often very helpful. In making many of these tests, it is sometimes more effective, if working with a dry powder rather than with a paint or enamel, to rub up a little color in a heat-bodied oil, and then making a pull-down on paper, as this furnishes a very thin film, which reacts very quickly to tests with caustic, etc., though sometimes it is necessary to study very carefully the behavior of the dry colors in the strong acids and alkalies as well.

### White Pigments

The white pigments and more particularly such opaque pigments as zinc oxide, titanium dioxide, lithopone, etc., are used in the lacquer and synthetic enamel industries to a greater extent than the fire process pigments, the fume pigments, or the chemical pigments.

These white pigments are the earthen colors and as such involve mining, washing, drying and in some instances calcining.

**ZINC PIGMENTS** — There are two types of zinc pigments that find extensive use in lacquer enamels — zinc sulphide and zinc oxide. The former comprise lithopone (Albalith) with approximately 30% ZnS and 70% BaSO<sub>4</sub>, technically pure zinc sulphide (Cryptone ZS) with approximately 98% ZnS, and an intermediate product, zinc sulphide-barium pigment (Cryptone BA) containing approximately 50% ZnS and 50% BaSO<sub>4</sub>.

The zinc sulphide is precipitated from a zinc solution, either alone or in the presence of barium; the crude pigment being subsequently calcined, wet milled, dried and disintegrated.

These products are used for pigmenting, the type chosen being determined by the strength desired, strength depending largely on the percentage of ZnS in the pigment. Because of the low pigmentation that lacquer vehicles permit, the higher strength types are preferred. Such enamels are white (either gloss or flat) and can be tinted off to any desired color.

Zinc oxides are made by either one of two dry processes. The direct or American Process comprises fuming zinc from mixed finely divided ore and coal and burning the zinc fume from the ore and subsequently

burning to zinc oxide in a separate operation. Being a fumed pigment zinc oxide requires no grinding. Because of the method of making, the French Process Zinc Oxide is the whiter and brighter of the two and the one ordinarily preferred when color in coatings is at stake.

In lacquer enamels, zinc oxide is used for its physical and optical properties — coloring, hiding, fineness — but more attention is being paid to its chemical qualities. Zinc oxide is distinctly basic in character and acts as a film stabilizer, neutralizing or preventing the formation of acid decomposition products and prolonging the flexible life of the lacquer. Yellowing is retarded and diminished at the same time, since the vehicle decomposition products tend to be yellow. Zinc oxide, being fungicidal, makes mildew more difficult to form. In exterior enamels its resistance to ultraviolet light protects the film.

Grades of zinc oxide are now made that are closely controlled as to particle size, but different grades vary quite sharply from one another in the mean diameter of the particles. The smaller size particle tends to greater reactivity and, therefore, effectiveness in producing those results that depend on this quality. These are the “Kadox types” and are relatively low in hiding power. The coarser grades have greater hiding power and are less reactive. Some grades are too coarse to have good pigment properties.

In some lacquer formulations, plasticising resins are used which are too reactive to permit the use of zinc oxide. Very recently an oxide of low reactivity (XX-505) has been introduced which combines medium size particles with normal zinc oxide hiding power and good pigmentary qualities. Its low degree of reactivity permits its use with certain reactive lacquer vehicles and enables the manufacturer to obtain zinc oxide benefits without excessive thickening.

In general, nitrocellulose lacquers lend themselves very well to pigmentation with combinations of zinc sulphide pigments to provide optical properties and zinc oxide for its chemical properties. Enamels of good working and packaging properties and film characteristics result.

**TITANIUM DIOXIDE** — Titanium dioxide exhibits a fine particle size, good color and is considered inert to lacquer and synthetic enamel ingredients. It is favorably received because of these desirable qualities.

The tendency of titanium dioxide, either pure or extended, to chalk freely in exterior lacquers, has long been a recognized disadvantage. Free chalking causes tinted finishes to fade and glossy finishes to become flat.

Combinations of titanium dioxide and antimony oxide are considered somewhat more satisfactory, although care should be used in determining a proper ratio to retard checking due to an excess of antimony oxide and chalking due to the titanium dioxide.

Grades of titanium dioxide, which show maximum resistance to chalking and fading in modern outdoor automotive lacquers, are "Rayox" O, "Rayox" Y and "Ti-Pure" Y.

"Rayox" CR or color-retaining titanium dioxide is especially recommended for use in nitrocellulose lacquers because of its resistance to after-yellowing. This is more marked in lacquers than in any other type of vehicle. Its resistance to discoloration during high temperature baking of synthetics is of interest to formulators. The color-retaining types of titanium dioxide are more difficult to grind than the regular types. In ball-milling, almost all pigments can be considered "overground," so where nitrocellulose finishes are prepared in that type of mill, the grinding difficulty is lessened or overcome completely.

### **Black Pigments**

There are three black pigments used in the lacquer and synthetic enamel industries: bone black, lamp black, and carbon black. The latter is used almost exclusively, as it affords a more intense color than any other type of black pigment.

**CARBON BLACK**—This pigment is produced by burning natural gas in the presence of an insufficient amount of air. Most carbon blacks are produced by the channel process; that is, they are deposited on channel irons, scraped free, bolted and packaged, whence they are ready for use.

Carbon black is presented to the trade either in the fluffy state or in an agglomerated form (clusters of minute particles). The ultimate particles of carbon black are submicroscopic and display strong cohesive forces as evidenced by their tendency to form agglomerates.

### CHEMICAL COLORS

With few exceptions, chemical colors, whether of organic or inorganic origin, are precipitates. A wide variety of raw materials is employed in their production, it being necessary for the manufacturer of a well-diversified line to employ several hundred raw materials, such as bichromate of soda, chlorate of soda, prussiate of soda, sulphuric, nitric, hydrochloric, and acetic acids, litharge, lead carbonate, aluminum sulphate, soda ash, caustic soda, copperas, barium chloride, tin crystals, sodium tungstate, various dyestuffs and intermediates, etc.

Mr. A. F. Brown, of Imperial Color and Paper Company, in an address delivered a few years ago before the American Society for Testing Materials said, "It is easy to write out theoretically the reactions involved in producing most chemical colors, but there is so much physical chemistry entering into the processing, that it is possible to produce colors varying tremendously in quality from the same raw materials, and one of the biggest problems of the industry is to produce successive batches of a given color that will be alike in all properties; and there is no question but that, everything considered, their manufacture is more involved than that of any other class of raw materials entering into the manufacture of colored protective coatings. The processing is usually carried on in tanks of varying capacities, made of various resistant materials, depending on the corrosion problems involved; and it is common practice to consider a precipitating tank, and several tanks to be used in preparing the various solutions as a 'unit.' In making a single color, it is frequently necessary to use as many as twelve or fifteen different raw materials. After the color has been precipitated, the next step is to remove by washing the various objectionable soluble materials that have been formed as a result of the reactions. Then the color is filter-pressed and the cake dried and ground."

Chemical colors can be roughly divided into two classes — inorganic and organic, and the organic colors can be again subdivided into the following types:

- (1) Precipitation of acid dyestuffs by such precipitants as barium chloride, calcium chloride, lead acetate, etc.

- (2) Precipitation of basic dyestuffs with tannic acid; tannic acid and tartar emetic; or "synthetic tans." Precipitation of basic dyestuffs with phosphotungstic acid or phosphomolybdic acid.
- (3) Diazotization of an amino compound and coupling with a second component (azo pigments or "ice colors").

The pure or most concentrated colors of the inorganic type are usually referred to as "C.P." colors, and when an extender, such as barytes, clay, etc., is added to a color of this type in making a weaker form, the color is designated as a "reduced" color. The pure or most concentrated forms of organic colors on the other hand are designated as toners. Originally the term "lake" was used to describe a color formed by the precipitation of a soluble dyestuff, but in recent years this designation has been used rather promiscuously and has lost its original significance to some extent, and the term is now sometimes used to indicate organic colors that are precipitated on such bases as aluminum hydrate, blanc fixe or gloss white, which is a combination of these two extenders.

### ORGANIC COLORS

Acid dyestuffs are the sodium salts of sulphonic acids, as well as such dyes as contain phenol groups, associated with nitro groups. Basic dyestuffs are organic bases, from which salts have been formed with hydrochloric, oxalic, or other acids. Intermediates are coal tar derivatives that have no color value until combined with other intermediates, or treated in such a way as to produce a chromophore, which is a grouping of the molecular structure that experience shows produces "color." Acid dyestuffs are usually precipitated with such precipitants as barium chloride, lead acetate or aluminum chloride. Formerly basic dyestuffs were precipitated largely with tannic acid, sumac or rosin soap, and lakes formed from these basic dyestuffs, using these precipitants, were more fugitive to light than lakes formed from the acid dyestuffs, but since the development of the methods for precipitating basic dyestuffs with phosphotungstic or phosphomolybdic acid, the situation has entirely changed, and today the most permanent lakes are those made from the basic dyestuffs precipitated with tungstic or molybdic acids.

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**INORGANIC COLORS****Yellow Pigments** ✓

**CHROME YELLOWS** — These are produced in a wide variety of shades, from the very pale canary or primrose to a comparatively deep red, which is known as C.P. deep chrome orange, the intermediate shades being often referred to as lemon, medium, etc. The lighter shades of chrome yellow are combinations of lead chromate with co-precipitated lead sulphate or other insoluble lead salts. The best quality medium yellow is as nearly pure lead chromate as can be produced on a commercial scale, and still run over 98 per cent lead chromate. The redder shades, known as chrome oranges, are basic lead chromates, that is to say, combinations of lead chromate and lead oxide, co-precipitated from basic solutions. These different shades vary in oil absorption, specific gravity, light fastness, etc. The lemon shades of chrome yellow have the highest oil absorption, and the deepest shade of chrome orange the lowest. The specific gravity varies from 5.6 to 7.0. Chrome yellows are permanent colors in the sense that they do not fade when exposed to sunlight, but they do darken, due to causes that are not well understood, the best quality of primrose probably darkening a little more than the lemon or the medium shades, while the best quality chrome oranges darken very little.

**ZINC YELLOWS** — Zinc yellow is a pigment produced practically on only one shade, about the same degree of redness as a C.P. primrose yellow. While it is generally referred to as zinc chromate, it is in reality a pigment, the exact composition of which is not too well understood, but it probably is a complex salt of zinc and potassium chromate. It shows less tendency to darken on exposure than does a primrose chrome yellow, but it has a tendency to bleed in water, which limits its usefulness as a color pigment, though it is undoubtedly this same water solubility which explains why it is such an excellent rust inhibitive pigment.

**CADMIUM YELLOWS** — The cadmium yellows made in this country are really not pure cadmium sulphate, with or without zinc compounds. They are produced in a range of shades, varying from that of C.P. primrose yellow to a C.P. light chrome orange. They do not

show the tendency to darken on exposure to light as do chrome yellows, but on weathering the durability is not always satisfactory, as there seems to be a tendency to oxidize to cadmium sulphate, which is a water soluble compound. They are not affected by hydrogen sulphide, are absolutely non-bleeding in oil and lacquer solvents, stand baking very well, are resistant to alkali, but are very sensitive to acids. Because of their high cost, they are used only for special purposes.

### Green Pigments

**CHROME GREENS**—Chrome greens are combinations of chrome yellow and iron blue in varying proportions, the procedure usually being to precipitate the yellow on the washed blue, though sometimes the yellow and blue are precipitated separately and then the two dilute suspensions pumped together before filter-pressing. Because they possess such excellent hiding power, it is possible to use large proportions of extenders with them, such as barytes and clay, in the manufacture of house paints. (Extenders are very rarely, if ever, used in pigmented lacquer enamels.) Alkaline extenders, such as whiting, should not be employed, for chrome greens are sensitive to alkali, due to the iron blue present. They are made in a wide range of strengths, and almost an endless variety of shades. Like chrome yellows, they show some darkening on exposure, but marked advances have been made in recent years in reducing the degree of darkening, and chrome greens are used more extensively than any other type of green pigment.

**CHROMIUM OXIDE**—Chromium oxide is the most stable green pigment known. Unlike chrome green, with which it is sometimes confused, it contains no lead or iron compounds, but is commercially pure  $\text{Cr}_2\text{O}_3$ . It is absolutely fast to alkali of any strength, is unaffected by the strongest mineral acids or hydrogen sulphide, and will stand extremely high temperatures, including ceramic heats. However, because it is lacking in brilliancy and is relatively low in tinting strength, it is used only for special purposes, where resistance to alkali, extreme light fastness, or some other characteristic is more important than brightness of shade.

**HYDRATED CHROMIUM OXIDE** — This pigment, which is also known as Guignet green, varies chemically from chromium oxide only in the fact that it contains water of crystallization, but physically it is entirely different, being extremely brilliant in shade, though quite transparent. It is much more expensive than regular chromium oxide, and is employed in only limited quantities. By combining it with a light shade of yellow, such as primrose chrome yellow and a white opaque pigment, such as zinc oxide or lithopone, it is possible to secure shades like that of Paris Green, and the paint or enamel will have equal durability, much better hiding and, of course, be non-poisonous.

### Blue Pigments

**IRON BLUES** — Iron blues are made by precipitating ferrous salts with sodium or potassium ferrocyanide, the white precipitate thus formed being oxidized with suitable oxidizing agents. Before the World War practically all iron blues were made from potassium ferrocyanide, but due to the scarcity of potash at that time, color manufacturers were compelled to work out methods using sodium ferrocyanide and an ammonium salt, and these methods were so successful and were so much cheaper, that at the present time little or no blue is being made from prussiate of potash. Iron blues are sold under a variety of designations, such as Prussian, Chinese, Milori, Bronze, Steel, etc., but these names have been employed so promiscuously during the past twenty years, that they have practically lost their significance, and the name under which an iron blue is sold is little or no indication of its physical characteristics. Iron blues possess good light fastness, but are extremely sensitive to alkali. Tints made from iron blue are not stable in the can, when made into paint, because the linseed oil acts as a reducing agent, and the pigment then reverts back to a white compound. Iron blues vary widely in oil absorption, texture, and shade, especially the tendency to develop the objectionable metallic sheen commonly called "bronze," when a lacquer is exposed. Unfortunately the blues which show the least tendency to bronze on exposure are the hardest in texture, and these types are probably one of the hardest color pigments to disperse of those used in paint.



## Red Pigments

**CADMIUM REDS** — Selenium is combined with cadmium sulphide in the production of these redder shades, some of which are really deeper than C.P. deep para toner, and are actually maroons. They possess the same general characteristics as cadmium yellows, but are much higher in cost.

## ORGANIC COLORS

### Yellow Pigments

**HANSA YELLOW** — This pigment is made by diazotizing amino compounds, such as meta-nitro-para-toluidine and coupling with second components, such as aceta acetanilide. It is made in several shades, but the one most generally employed is about the same shade as C.P. lemon chrome yellow, has a specific gravity of about 1.47 and a relatively high oil absorption. This color when used full strength is undoubtedly the most permanent yellow pigment available, as it does not even show a tendency to darken after long exposure. Its tinting strength is four to five times that of chrome yellow, but its actual hiding power is no greater; that is to say, it requires about as much Hansa yellow per gallon as chrome yellow to secure the same degree of hiding.

**TRANSPARENT YELLOW LAKES** — Transparent yellow lakes are usually made by precipitating dyestuffs, such as tartrazine, with barium or aluminum chloride on an aluminum hydrate base. These colors do not possess good permanency, but they stand baking temperatures up to 300°F for one half hour very well, and are usually employed in applications on tin or for making transparent stains, where better permanency is desired than can be obtained from dyestuffs.

### Green Pigments

While some green lakes are still made from dyestuffs such as acid green, precipitated with barium chloride, most of the green toners now being used are made from dyestuffs, such as malachite green, precipitated with tungstic or molybdic acid. These colors, while not nearly as permanent as chrome green, are very much more brilliant and are being used in increasing quantities for making tints or interior enamels that will be stable in the can.

## Blue Pigments

**BLUE TONERS** — Extremely brilliant and very strong colors can be made from such dyestuffs as Victoria blue, methyl violet, etc., and if these colors are precipitated with tungstic and molybdic acids, they are very much more permanent than if precipitated with such materials as tannic acid. The tungstic toner made from Victoria blue, for example, has about thirty times the tinting strength of ultramarine blue, but, of course, is inferior in permanency. Development of synthetic resins has further complicated the stability of green and blue tints in the can, because in addition to the reducing action of the varnish with some of the synthetic resins now being used, there seems to be a direct reaction between some resins and the colored pigment, if chrome green or iron blue are employed. Consequently for interior enamels and paints, tungstic-molybdic precipitated blues are being used in increasing quantity, and while such tints are not fast to light, they will be stable in the can, if basic pigments such as zinc oxide or lead carbonate are not employed and alkaline solutions are not used. They are also used for obtaining various shades of interior enamels where brilliancy is of more importance than light fastness, and for the "bleaching" of whites, this color correction being accomplished, of course, by the neutralizing effect of the "complementary" color thus added.

## Red Pigments

**TOLUIDINE RED** — Toluidine toner is made by coupling meta-nitro-para-toluidine with beta-naphthol. While it is made in several shades, the range is comparatively narrow. When used full strength, it is one of the most permanent opaque organic reds available, and is commonly employed for the better class of bulletin work, and where brightness, non-bleeding and permanency are desired. The non-bleeding characteristics of a properly made toluidine are affected to a considerable extent by the composition of the white paint, and a long-oil paint should never be employed, but rather a short-oil paint that will dry in a minimum time. Toluidine bleeds in lacquer coatings.

**PARA REDS** — Para reds are made by the same general process as toluidine reds, except that para-nitro-aniline is coupled with beta-naphthol. While toluidine has a little better permanency, para toner

possesses sufficient permanency, so that it can be used anywhere its shade is satisfactory, and bleeding is not a factor, and it is much lower in cost. It does not stand baking as well as toluidine.

**LITHOL REDS** — Lithol reds are made by coupling Tobias acid (2-naphthylamine — 1-sulphonic acid) with beta-naphthol. The sodium salt is first formed, and it gives a color of a relatively yellow shade. When darker shades are wanted, the sodium lake salt is converted to the barium or calcium salt, the barium being deeper than the sodium and the calcium deeper than the barium. The sodium salt is not as fast to light and does not withstand heating nearly as well as the barium and calcium salts, and if there is any difference in light or heat resistance between barium and the calcium, it is in favor of the calcium. Lithols are of two types: "regular" and "bronze free." In the bronze-free type there is introduced during the precipitation a resin which imparts to the finished color a brightness of shade and additional tinting strength that cannot be obtained in any other way. This additional brilliancy is very often desirable, but these resinate lithols are more active in some vehicles than the regular lithols, do not bake as well, are less permanent and have less hiding power. All lithols, however, darken on exposure, that is to say, they tend to go "blue" after a few months, and while they are used sometimes for outside enamels, because like toluidine they are non-bleeding, stand heat well and are much lower in cost, they nevertheless do not possess too good light fastness, and when used, it must be with the mental reservation that durability is being sacrificed to obtain lower costs.

By chlorinating para-nitro-aniline before it is coupled with beta-naphthol, a red pigment is produced that is sold under such proprietary names as Tanager Red Toner, a fire red toner that is somewhat yellower in shade than toluidine, and has about the same properties as regards non-bleeding and permanency. This color is employed where a yellower shade of red is desired than can be obtained from toluidine.

## Maroons

**BORDEAUX LAKES** — Before the advent of lacquers, a barium precipitation of the dyestuffs known as Bordeaux was used extensively

for automotive maroon, but this color has no durability in lacquer, and it has been necessary, therefore, for the color manufacturer to develop entirely new types of pigments for lacquer work.

**MADDER LAKES** — These colors are made in several shades by combining synthetic alizarine with aluminum and other salts, the resultant colors possessing excellent light fastness and being non-bleeding. However, they are relatively transparent, and for this reason have been superseded to a considerable extent in lacquer work by the more opaque type of maroons, although they are still used to some extent.

**OPAQUE MAROONS** — There are a number of varieties of these colors, some being made by combining Tobias acid with beta-oxy-naphthoic acid. This type of color has relatively good hiding, and a fair degree of permanency, but it is entirely hard in texture, and, therefore, difficult to disperse, and as a class, the maroon pigments available today are less satisfactory than those in any other color group, because all of them are very expensive, and do not possess a combination of good hiding, good permanency, good texture, good depth, and good brilliancy.

### Fire Process Pigments

**ULTRAMARINE BLUES** — This fire process pigment is made from a combination of clay, silica, soda ash, and sulphur, which possesses a brilliancy that cannot be secured from any other color. It is very fast to light in the sense that it is not decomposed by light, but unfortunately there is a marked change in the refractive index of the pigment on weathering, which to the uninitiated appears to be fading. Unlike iron blues, ultramarine blue is very resistant to alkali, but is very sensitive to acids.

### Inert Pigments for Lacquer

The inert pigments used in lacquer to impart a rubbed finish appearance are zinc stearate, zinc palmitate, diatomaceous earth, etc. These pigments possess no opaque coloring properties and are customarily "ground" in pebble, ball or on roller mills into a paste or base. This paste or base is incorporated into the prepared transparent lacquer in varying proportions to produce a  $\frac{1}{2}$ ,  $\frac{3}{4}$  or dead flat finish.

## Behavior of Colored Lacquers in Tin Containers

In order to determine whether lacquer enamels showed any color change after being stored in cans, the following investigation and results are noted. Regular stone-mill dispersed color pastes were used and mixed with a nitrocellulose base in the proportion of two pounds per gallon. Resin solution and plasticiser were added to form a finished outdoor lacquer enamel:

### White

TITANOX — Showed slight yellowing after one month. Discoloration did not increase after four months.

ZINC OXIDE — Showed slight yellowing but did not increase appreciably after four months.

LITHOPONE, LOW OIL — Showed a yellowing comparable to zinc oxide.

LITHOPONE, HIGH OIL — Showed a yellowing in less than three weeks' time. Discoloration did not increase in four months' time.

WHITE LEAD — Shows a yellowing and discoloration after it comes in contact with the lacquer solution. Within three weeks the color darkens to a gray-yellow cast.

### Yellow

The following yellow pigment pastes were observed after 0, 2 and 4 months' standing in tin containers and no color change could be noticed:

CHROME YELLOW LIGHT — Four months.

CHROME YELLOW MEDIUM — Four months.

ZINC YELLOW — One month.

FERRITE YELLOW — Three months.

CHROME ORANGE — One month at which time changes to a muddy yellow and shows decided chalkiness.

ORANGE CADMIUM LITHOPONE — Turns lighter in one month standing, but is not chalky.

RAW UMBER — Two months, no change.

BURNT UMBER — Two months, no change.

### Greens

LIGHT CHROME GREEN — One month, changes slightly yellow.

DEEP CHROME GREEN — One month, changes slightly yellow.

MEDIUM CHROME YELLOW — Four months, no change.

MILORI GREEN — Two months, no change.

GREEN LAKE — Four months, no change.

### Blacks

LAMP BLACK — One month, no change.

### Reds

TOLUIDINE TONER — One month, no change.

RAW SIENNA — One month, no change.

MADDER LAKE — SCARLET LAKE — MAROON LAKE — All transparent colors, no change noted — one month.

DARK LITHOL TONER — One month, darkens.

TUSCAN RED — One month, shows muddiness and darkens to brownish cast.

LIGHT PARA TONER — Darkens after one week and shows muddy appearance.

### Blues

ULTRAMARINE BLUE — No change noticed — it becomes of transparent nature and could not be noticed had there been a change.

PRUSSIAN BLUE — Darkens slightly in one month. No further change at four months.

### Dispersion of Pigments

Pigments are "ground" or dispersed into vehicles by passing over frictional surfaces, such as roller or stone mills. "Grinding" is considered a problem of contact between liquid and solid and includes adsorption, wetting, deflocculation, dispersion and floating. Grinding produces a static electrical phenomenon in which the particles become charged with static electricity and are attracted to each other, forming agglomerates in the vehicle. Pigments must be properly wetted in order to break down cohesive forces by penetrating through the clusters, particles, or agglomerates. This action lowers the surface tension of the pigment. Pigment and vehicle combina-

tions which contain uniform charges (positive or negative according to the pigment used) show good dispersion by microscopic examination and markedly influence color intensity.

Grinding produces a "paste" which is further added to clear lacquer bases. In synthetic enamel technique, the pigment is dispersed directly into the resin solution. Other means of dispersing pigment is by ball or pebble mills which are closed cylinders, banbury mixer, double mills or by so-called high speed colloid mills.

Each type of mill possesses advantages and disadvantages, depending upon many factors, such as the nature of the grinding vehicle employed, size of the batch, etc.

Roller mills give large production and are very satisfactory equipment, especially so when the vehicle used is non-volatile, or nearly so, and possesses sufficient "tack" to secure efficient grinding. They are easy to clean and quick changes in shades can be made.

Where the dispersing vehicle contains large portions of volatile liquids and where it lacks "tack" or where the size of the batch is small, the stone mill can be used to best advantage. The output is limited and in no way comparable to roller mill production.

Ball or pebble mills require little or no supervision during the "grinding" operation. They do, however, require a long time to attain proper fineness of pigment texture. In closed cylinders of this type it is possible to use very volatile liquids and vehicles which will permit of good "wetting" of the pigment. While it is possible to produce large batches at one discharge of the mill, it is not considered "elastic" equipment in that it is troublesome to make a radical change in shade due to cleaning difficulties. (It is the author's belief because of the improper dispersion and high volatile proportion of the vehicle that gloss is sacrificed.)

### Dispersion of Carbon Black

Since carbon black is considered of submicroscopic size, it cannot be "ground" in the sense of cutting through the particle and forming finer divisions; therefore, it follows that the satisfactory use of carbon black by the protective coating industry is dependent upon the degree of dispersion (flocculation). Usual methods of grinding or dispersing carbon black are described elsewhere in this chapter and

in general include stone, roller and ball mills. The finesse of grind or degree of dispersion will affect the color intensity, resultant gloss, and the durability of the enamel it may form. Good dispersions are associated with proper wetting and stability of the dispersion.

A typical carbon black roller mill "grind" is as follows:

|                         |                     |              |
|-------------------------|---------------------|--------------|
| Carbon black .....      | 4.00% b.w.          |              |
| Dibutyl phthalate ..... | 12.00               |              |
| Blown castor oil .....  | 40.00               | Total solids |
| Resin solution .....    | 44.00               | 78.00%       |
|                         | <u>100.00% b.w.</u> |              |

### Dispersion without "Grinding"

The dispersion of "soft" texture pigments may be carried out without preliminary "grinding." The pigment should be well distributed with the cellulosic compound and pigment wetted thoroughly with a non-solvent (a part of the formula) to form a weak gel. The agitator is set in motion and during this operation the pigment is agglomerated and occluded by the cellulosic compound (as a weak gel), which possesses low shearing resistance and low tensile strength. Solvents are then added slowly with thorough mixing to form a final swelling of the gelled cellulose and just as the colloidal solution takes place at the liquid gel boundary, a gel structure of relatively high tenacity is formed. Hence the pigment particles occluded are torn apart during the final swelling and actual solution, since the cohesive forces in the final gel greatly exceed the cohesive forces which maintain the status of the ultimate pigment particles in the agglomerated unit.

Prewetting of pigments (fitting a pigment for dispersion) may be enacted, in which the surface properties of pigments may be greatly altered, but its composition will remain constant. The selectivity of wetting liquids is necessary. This applies to volatile as well as non-volatile portions of the vehicle. A pigment of organo-philic nature requires select volatiles of the same type, although a liquid slightly hydro-philic (a polar liquid) is sometimes necessary. The pH value of a pigment (if acidic) would indicate that in the prewetting or dispersion operation, a basic or highly alkaline substance should be employed. (Satisfied polar non-polar substances possess a high elec-



trical moment.) This may have a bearing on correcting some of the common pigmented enamel faults, particularly as regards dispersion, settling, flocculation; and may even influence color stability.

### Colloidally Dispersed Pigments

Pigments that have been colloidally dispersed in nitrocellulose and plasticiser and presented to the trade as solid chips or in granular form have met with great favor.

The pigment "grinding time" is eliminated and the manufacture of enamel is reduced to a simple mixing operation. In this solid form the ratio of pigment to nitrocellulose to plasticiser is generally flexible enough to allow for direct substitution in the average lacquer enamel formulation.

These chips may be dissolved in the usual lacquer solvents to give a paste in which the pigment is completely dispersed in colloidal form. Standard means of dispersing pigment (stone, roller and/or ball mills) is not considered as efficient as pigment prepared by this manner. Any undispersed or reagglomerated pigment by stone, roller and/or ball mill "grinding" may be considered directly responsible for loss of gloss in an enamel, and may cause lack of stability through which settling may result. It is a recognized fact that more thoroughly dispersed pigments (regardless of the means by which dispersion is enacted) will increase the covering power of a given enamel film, will increase the outdoor durability and will produce enamel films of greater color depth or intensity.

Greater pigment concentrations are found in these solid chips, as evidenced by the following compositions:

| WHITE                                     |                  | BLACK                                     |                  |
|-------------------------------------------|------------------|-------------------------------------------|------------------|
| Titanium dioxide .....                    | 50% b.w.         | Carbon black .....                        | 13% b.w.         |
| $\frac{1}{2}$ Second nitrocellulose ..... | 34               | $\frac{1}{2}$ Second nitrocellulose ..... | 67               |
| Dibutyl phthalate .....                   | 16               | Tricresyl phosphate .....                 | 20               |
|                                           | <u>100% b.w.</u> |                                           | <u>100% b.w.</u> |

In dissolving colloidally dispersed base colors, it is advisable to resort to "soaking" or "swelling." This is accomplished by adding thinner, which is a part of the formula, and agitating until swelling occurs. This point is reached in normal production size batches in about two hours. A thixotropic condition will be noticed and a load

placed on the motor. Shearing or agitation should be allowed to continue until the color base is well broken up at which point the balance of the thinners, vehicle, etc., is added.

Under certain conditions (where whites, yellows, greens, and similar "soft" pigments are employed) centrifuging of the enamel is not considered necessary.

### Particle Size of Pigments

The microscope is used as a direct method of determining particle size of pigments. If the particle is of submicroscopic size, the ultra-microscope (dark field count method) is used with some success. Other methods of measurements are: sedimentation, elutriation, or surface measurements.

The study of particle size of pigments and its relationship to dispersion, maintenance of gloss, durability and stability of enamels is receiving more consideration in recent years. Among the softer types of pigments as zinc oxide, lithopone, titanium dioxide, chrome yellows, chrome greens, etc., where it is an easy matter to reduce the agglomerates by "grinding," particle size is considered of lesser importance. It is among the "harder types" of pigments, e.g., iron blues and certain reds that particle size is of prime concern. This is especially true of carbon black which is of microscopic size (about 1000 Å-500 Å).

It is thought that the ease with which dispersion is enacted is directly associated with pigment particle size. This size or grading is considered an important property which (the surface properties) will determine its behavior in a coating vehicle.

Improperly dispersed pigments may become reagglomerated and when used in a coating may be directly responsible for loss of gloss, lack of durability, lack of coverage, sedimentation and lack of stability in the package.

### Flushed Colors

Well-directed efforts on the part of pigment manufacturers have indicated that better values of pigments may be attained by means other than technique of precipitation, calcining, etc.

Flushed colors are an example and are referred to as pigments that

have been transferred directly from an aqueous press cake to a paste in oil or varnish. The process of flushing is completed in vacuum mixers which remove the moisture.

Pigment particle size, wetting, and dispersion influences are important factors which favor flushed colors. Flocculation and/or reagglomeration of the pigment is not present. The flow, elimination of grinding operation, greater degree of gloss, reduction of pigment settling in the can, chalking and oil absorption variables are a few of the desirable values found in flushed colors.

#### REFERENCE

Special acknowledgment is accorded Mr. A. F. Brown of Imperial Color and Paper Company for certain information contained in this chapter on Chemical Colors.

## PART II

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### CHAPTER VII

#### PLANT AND EQUIPMENT

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In designing and equipping a modern manufacturing unit, consideration should be given: (1) location with respect to railroad siding, etc.; (2) raw material storage and operating space; (3) amount and type of lacquer to be manufactured; (4) number of nitrocellulose base solutions, resin solutions, thinners, and pigment pastes for storage; (5) floor space, type and location of apparatus.

The following is a suggestion for a manufacturing unit, which would comprise six main buildings as follows: (1) manufacturing unit; (2) control laboratory and office; (3) nitrocellulose magazine; (4) resin storage; (5) drum cleaning; (6) shipping and receiving. (See illustration No. 1.)

The manufacturing unit would involve a one and one half story fire-resistant building which is divided into two sections by a fire wall and the roof plan is brought to a peak, which is fitted with wire glass encased window frames. These windows are operated on an endless chain and a tooth-gear arrangement and may be opened or closed at will. This feature permits well-lighted working conditions. A hydraulic elevator is located within the unit.

There are well-founded arguments in favor of horizontal operations which would involve many buildings, but from the standpoint of compactness, the above plan should meet with great favor.

#### **Mezzanine Floor**

Here is located a series of three vertical iron mixing tanks which are set in the floor. The tops of the tanks are level with the floor and

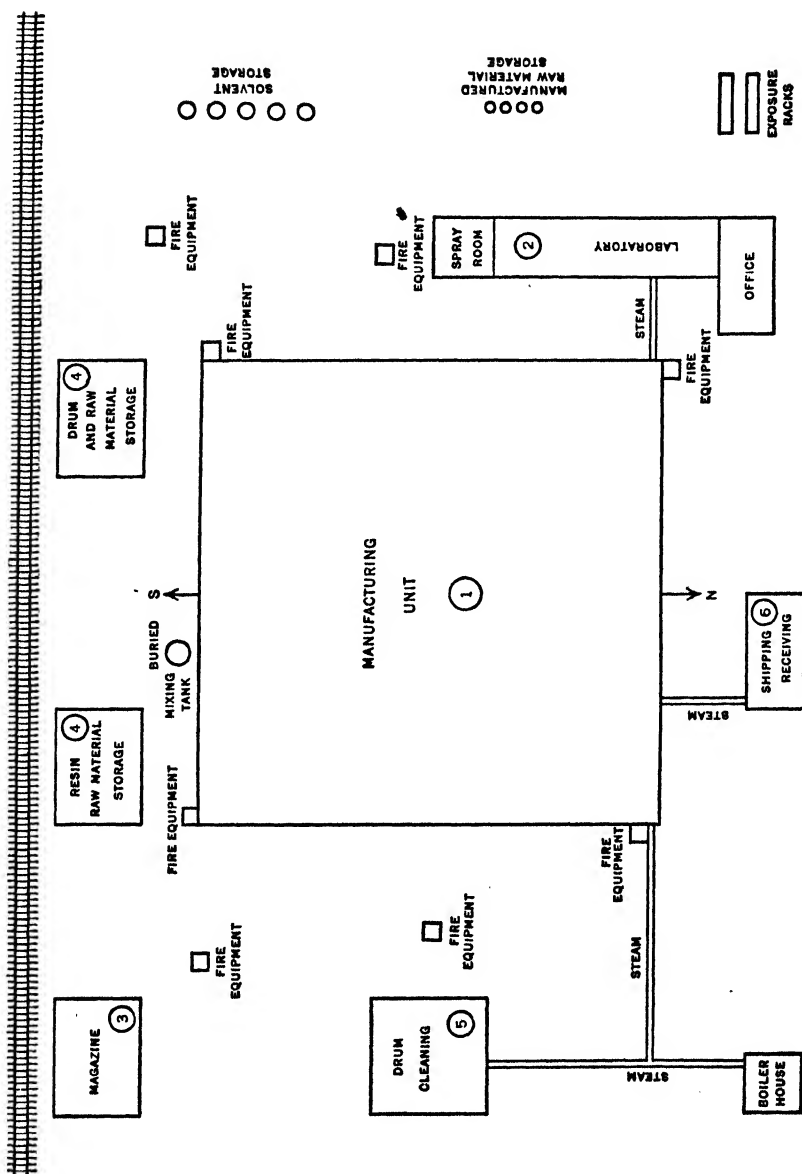


FIG. 1. Lacquer plant

are fitted with a double rim manhole cover. The cover fits loosely between two rims and the space between the rims may be filled with solvent to insure absolute airtightness. The cover is made of bronze to insure freedom of sparking. This series of three tanks are of 1000 gallon capacity and protruding through the mezzanine floor are re-enforced with I-beam girders on a frame located on the ground floor. These three 1000 gallon tanks are utilized for dissolving nitrocellulose; for dissolving bold resin and clear synthetic varnish and for the manufacture of clear lacquers. Such solutions may be filled into drums and enter into the manufacture of colored lacquers or synthetic enamels as base solutions, or may be pumped into the storage tanks outside the building. The tanks are fitted with horizontal fixed blades protruding from the shaft and stationary wing blades which are attached to the side of the tank. The side wing blade is fitted so that the stationary series of four are spaced between the three blades attached to the shaft. The lower and upper blades on the shaft are tapered in such a manner that the action produced is that of throwing the solution from the bottom to the center and from the top to the center, thus producing a turbulent action. The vertical tank shaft is extended several feet above the top of the tank to a line of shafting, which in turn is passed through a herringbone gear and the right angle shafting then attached to a  $7\frac{1}{2}$  horsepower motor which is set on a shelf outside the building. To keep the shaft trued, a flexible gasket is inserted between the motor and herringbone gear. A gear clutch is fitted to each tank. The movable gear (clutch arrangement) is equipped with brass fittings in order to minimize sparking. The shaft is passed through a stuffing box which insures minimum loss through evaporation. Raw materials, when entering these tanks by weight, have previously been weighed in either the nitrocellulose magazine or resin storage, etc., which minimizes any spillage or loose nitrocellulose lying around the building. The floor surface immediately adjacent to the tanks is covered with metal sheets of spark-proof nickel-lead composition. The remaining floor space of the mezzanine is constructed of sheet iron of a corrugated nature. A hot bituminous solution is applied over this sheet iron and heavy tar paper is laid over the surface. Whenever this shows signs of wear, additional applications of bituminous solutions may be applied. A

semicircular brass fitting is placed over the manhole cover when material (nitrocellulose or resin) is charged into the mixer. This permits of tilting an openhead barrel or drum and freely charging the mixer. This fixture likewise blocks out the tendency to fill the double groove. These mixers are solvent charged through a two inch pipe line. The introduction of such solvent is maintained at the side of the mixer and introduced against a baffle plate, at an angle which permits the solvent to flow down the side of the mixer and prevent static electricity from developing. A vaporproof switch on this floor is used to start and stop the battery of mixers. Through the manipulation of control valves, this switch may be used for starting the pump at the buried solvent mixing tank; for pumping materials directly into these tanks, or may be utilized for pumping nitrocellulose or resin solutions direct to tank storage outside the building. This switch may be used when a combination of liquids is to enter a given batch; the liquids having been previously prepared in the buried mixing tank. Control switch may be used at this point (switch and pump control) or at the mixing tank itself. If a straight solvent is to enter the tank, the material is passed by volume through the exactometer. Here the operator, first manipulating his valve for a clear line, changes his position to the solvent pump room. If plasticisers or flattening agents are introduced, it is customary to use measuring kits. Resin solutions are introduced over a resin pump line.

Strategically located escape hatches are provided on this level and a stairway leading to the ground floor is located midway on the mezzanine floor. Fire-fighting equipment is located on all floor levels. The doors leading to the escape hatches all open outwardly and will open at slight pressure. A one quarter inch vent pipe, properly screened, is fitted to each tank cover and extends about two feet above the roof of the building.

Six 300 and six 600 gallon mixers of the same type as previously described are located on the mezzanine deck and are utilized for the manufacture of pigmented lacquers. Instead of these mixers being flush with the floor level, they are elevated about three or four feet and protrude through the mezzanine to the discharge level on the ground floor. The charging of these mixers follows the principle described in the charging of the 1000 gallon mixers. A portable scale is

used for weighing purposes. Motors are placed outside the building on a shelf and operation is by finger-tip control push buttons. All tanks, mills, and machinery are properly "grounded."

In the manufacture of colored lacquers, a batch of nitrocellulose may be dissolved in the large tank and pumped into the mixers; the nitrocellulose may be dissolved in the "colored lacquer tank" or may be pumped from the outside storage tanks. Amounts involved may be controlled by tank measurements or may be passed into smaller measuring kits, then into the tank. Heavy resin solutions may be pumped over the gum pump, through the exactometer and passed into the tank. The solvents are measured and pumped into the tank (measurements are volumetric and passed through the exactometer). If in the event the resin solution is of either a four or six pound cut, it may enter into the tank in combination with the solvent, both are mixed together in the buried tank and pumped direct, involving but the one operation. Heavy synthetic resin solutions are added to the mixers by hand from measuring kits.

### Ground Floor

This floor is used as a filling deck. Here clear, flat, or colored lacquers or synthetic enamels are filled into various sized containers. Such products may or may not pass through the portable clarifiers. The solvent pumping room which distributes solvent to any floor level, outside tanks, etc., is located on this floor. Here, by valve control, any individual solvent or combination of solvents, resin or nitrocellulose solutions may pass through the pump and/or exactometer into any individual mixing tank. Immediately outside this room is a homogenizer for the manufacture of lacquer emulsion coatings.

The grinding room is located on the ground floor. This room is separated from other activities by a sliding door and a fireproof wall. Here are located two 50 gallon pebble and one 500 gallon ball mills, one 2 roller, one 3 roller and one 5 roller mill, one colloid mill and four 30 inch stone mills which are fitted with hoppers and change can mixers. All grinding of pigments for lacquer pastes and grinding of synthetic enamels is conducted in this room. The machinery is operated by motors located on shelf outside the building and are all controlled by finger-tip start and stop arrangement fitted in vapor-



proof casing. Stone mills and hoppers are fitted with chain drive, while the roller mills are operated on a separate motor and controlled by switch attached to the mill itself. An overhead chain hoist is provided to facilitate upper stone removal and cleaning; this is located over the line of stone mills. Ventilation outlets are located at the floor base in this room. Approximately two thirds of the roof over this section is given over to adequate lighting through a peak arrangement in the roof plan. Previously prepared grinding vehicles for lacquer pastes are filled into drums and placed on racks outside this room. Synthetic resins for enamel grinding are also located on prepared racks. A dough mixer is available for extra heavy solutions, fillers, and similar manufacture.

### **Buried Tank for Thinner Manufacture**

This represents a tank of 1500 gallon capacity in which the bottom is concave and the top flush with the ground surface. This tank is set in cement and is used expressly in the manufacture of thinners. The various solvents are measured into the tank through an exactometer and agitated through control valves by passing through the solvent pump to a blind valve shut-off, dropping back into the tank. The thinners may be passed from the tank over the pipe line and through an India linon covered funnel into drums for shipment. This buried tank is provided with vent pipe extending about two feet above the roof of the building.

### **Solvent Storage**

In a corner of the plant ground and adjacent to a railroad spur track are buried solvent tanks and tanks which are elevated on a cradle of concrete framework. Each elevated tank is protected by a wall in the event of a fire. These tanks represent normal tank cars with the exception of the frame and truck. In the instance of buried tanks, the conning tower is completely boxed to permit frequent examinations. Solvents, which represent the most frequently used commodities, are placed in these tanks which are filled by gravity or pumped from the car on the railroad siding. Buried tanks of 1000 gallon capacity are provided outside the manufacturing unit, and are utilized for the lesser used solvents. In like manner, these are passed

through the exactometer and either distributed throughout the plant or into the buried mixing tank for the manufacture of thinners. These tanks are individually equipped with one quarter inch vent pipes. Solvents are likewise secured in drums which are covered with burlap sacks in yard storage and are frequently wetted with water during the summer months. This cools the drums and keeps the temperature down, which permits only a minimum evaporation. When such drum solvents are to be used for manufacturing purposes, they are brought to the buried thinner tank, where through valve control they may be passed through the exactometer and over the various lines into any tank, or may be pumped directly into the buried tank. These drum solvents are located away from the manufacturing unit.

### **Nitrocellulose Storage**

Nitrocellulose is received in open-head drums wetted with 30% alcohol. (See illustration No. 2.) The drums are placed in the magazine which is a concrete building. This building is isolated from the manufacturing unit. The drums are placed in the magazine on their sides, which permits an even distribution of the alcohol content. This distribution of alcohol influences the rapid solvation of the nitrocellulose and also the viscosity of the finished product. For plant use, nitrocellulose is always drawn from the magazine. Drum overflow of nitrocellulose is placed on skids adjacent to the magazine and covered with burlap sacks which are wetted with water during the summer months. As the drums are withdrawn from the magazine, they are replaced with drums from outside storage. A drum of nitrocellulose is never broken or partly used. The entire content of the drum is used as the basis of all formulae, rather than from a nitrocellulose base. These drums are either 164 or 193 pounds net weight.

### **Resin Storage**

Outlying buildings from the manufacturing operations are utilized for gum and drum storage. Here the cases, bags, barrels, or drums of various gum-resins or synthetic resins are stored until needed. The building provides adequate protection from the weather. A gum crusher is placed inside the building and is provided with a fan

whereby excess dust is removed. This crusher is used to break up the larger lumps of the gum-resin. A portion of this building is used for other raw material storage.



FIG. 2. Open drum of nitrocellulose

### Drum Cleaning

Caustic soda solutions and similar water soluble alkalies of various concentrations are used as a means of drum cleaning. The bungs are withdrawn and the drum is immersed into a receiving tank. A one quarter inch steam line is inserted into the caustic solution and heated to a slight bubble-boil. After about an hour's immersion, drums are withdrawn by means of a chain block and are rinsed with

water. Water is drained, the excess is taken up with rags and a solvent mixture added to pick up minute traces of water. A double unit belt driven device, having the action of rotating and tumbling end over end is used quite extensively. Cleaning is obtained through chain inserted with the cleaning solution. There are several patented cleaning solutions finding preference over caustic soda. These solutions may be directly substituted for the caustic soda and are concentrated

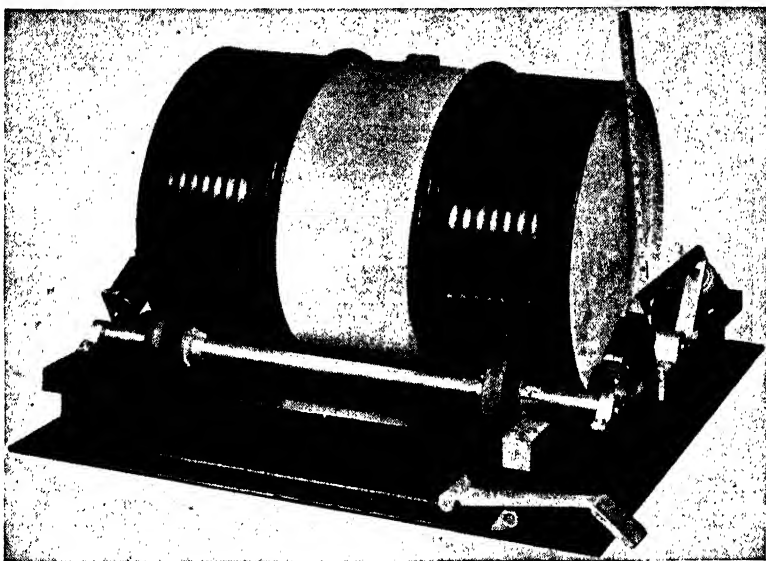


FIG. 3. Drum cleaner

*Vol-U-Meter Co.*

to the extent of six to eight ounces powder per gallon of water. (Illustrations Nos. 3 and 4 show types of drum cleaners, with automatic lifting device.)

Means of ascertaining whether a drum has been satisfactorily cleaned and, after inspection, whether such a drum is ready to accept lacquer has always been a matter of guesswork. This is because of the inability to thoroughly inspect the inside of the drum. An electrical extension cord with an explosive-proof light bulb has been used to good advantage. This cord with metal guard for the light bulb and covering for the cord which is inserted into the drum has met with great approval. There has been the great possibility of exposed elec-

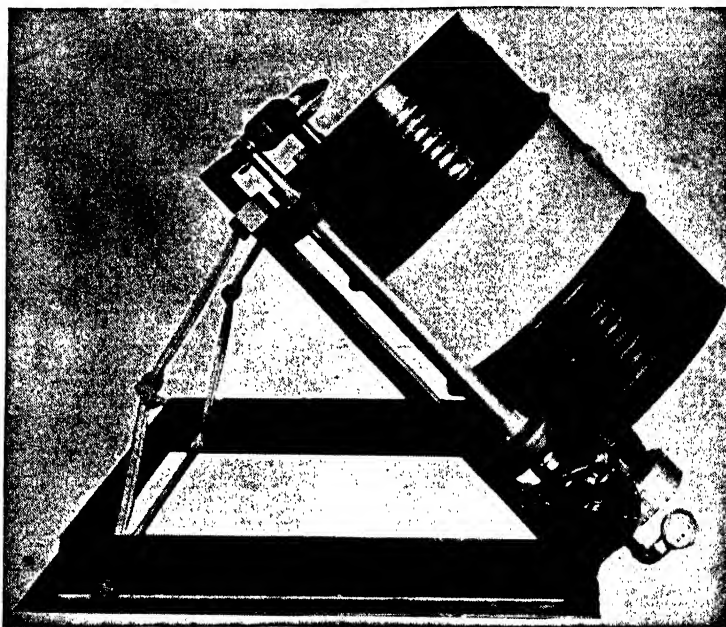


FIG. 4. Drum cleaner

*Vol-U-Meter Co.**Vol-U-Meter Co.*

FIG. 5. Drum inspection lamp

tric wire through frictional contact, but such a feature is eliminated in a comparatively new device termed a Tankoscope. This is a small periscope fitted with an explosive-proof light bulb and an eyepiece, having an extension cord protruding near the eyepiece. Such a device is in every sense a precision instrument. A number of lenses give a clear, bright, and undisturbed slide which is provided for eye adjustment. (Illustration No. 5 illustrates a form of safety lamp which meets with great favor.)

### Laboratory and Office

This separate building contains formula files and records. Batch tickets originate in the office and are likewise returned and checked for yield, costing, and raw material stock. All materials manufactured in the plant are brought to the laboratory for approval. Here a standard retain sample is produced and the batch is checked. Material is not shipped unless first approved by the laboratory. Lacquer thinners are checked for toluol dilution factor; nitrocellulose and synthetic resin solutions are checked for total solids; wood and metal finishing materials are checked for viscosity, film and color, etc. Aside from control, a portion of the laboratory is assigned for research and analytical work.

### Spray Room

This room is located adjacent to the laboratory. Here a production size spray booth equipped with exhaust fans is used. Wood panels of various sizes are used for testing of wood finishing materials. A retained standard is applied to one half of the panel, alongside which is placed the batch under test. Material is tested in all manners which would influence such a finish. When colored lacquers or synthetic enamels are under test, two panels are sprayed: one in the same manner as described for wood finishes, the other a full panel. A previously sprayed panel (standard for color) having been maintained at the time the original development was approved, is compared alongside the full sprayed panel, rubbed and polished and color match rated in white light (sunlight) and under a blue lamp. An oven is provided for synthetic enamels in a separate unit of the spray room.

### **Outdoor Exposure Rack**

Suitable space is provided in one corner of the plant lot for a set of exposure racks. These wooden racks are intended for panel exposure at a 45° angle. Additional panel exposure space is provided on the roof of the laboratory building.

### **Fire Equipment**

Strategically placed throughout the plant are various sized cylinders of liquid carbon dioxide, fire foam, sand, etc. In like manner larger sized units are placed outside the plant buildings. Water sprinkler and steam systems are also evidenced in the buildings.

### **Manufacturing Equipment — Mixers**

Nitrocellulose, a colloid of fibrous structure, when placed in a tank or mixer of solvents or liquids shows dissolving properties. The fine downy mass of the outer structure is readily and completely dissolved, while the inner section remains lumpy. For this reason the mixers used in lacquer manufacturing are equipped with paddle arrangement which produces great shearing action. The horizontal type of mixers are seldom used; however, in the earlier days of lacquer manufacture such equipment was considered standard. These horizontal mixers have been replaced with the vertical type which are used both for low and high viscosity nitrocellulose solutions. (See illustration No. 6.) These concentrated nitrocellulose mixtures are satisfactorily dissolved in this type of mixer. The mixers may be secured from several manufacturers and are especially designed to meet manufacturing conditions with respect to size and space. These mixers are generally of the gear driven type. Where a smaller type is required, available sizes range from a 5 gallon laboratory portable to a 1000 or 1500 gallon size. They are equipped with heavy steel blades for nitrocellulose "cutting" or they may be of the propeller type for dissolving and manufacture of lower viscosity lacquer products. They are available singly or in a battery of four to eight and are fitted with airtight covers which eliminate the evaporative factor. These tanks or mixers may be operated independently or collectively and may be secured with belt, chain or direct motor drive. A high speed mixing tank has recently been introduced to the lacquer trade. (See illustra-

tion No. 7.) This mixer is controlled by an individual motor which is fitted with shaft and propeller. It is inserted into the tank and may be disconnected and used for similar purposes in other such mixers or may be of the stationary variety. For the low viscosity

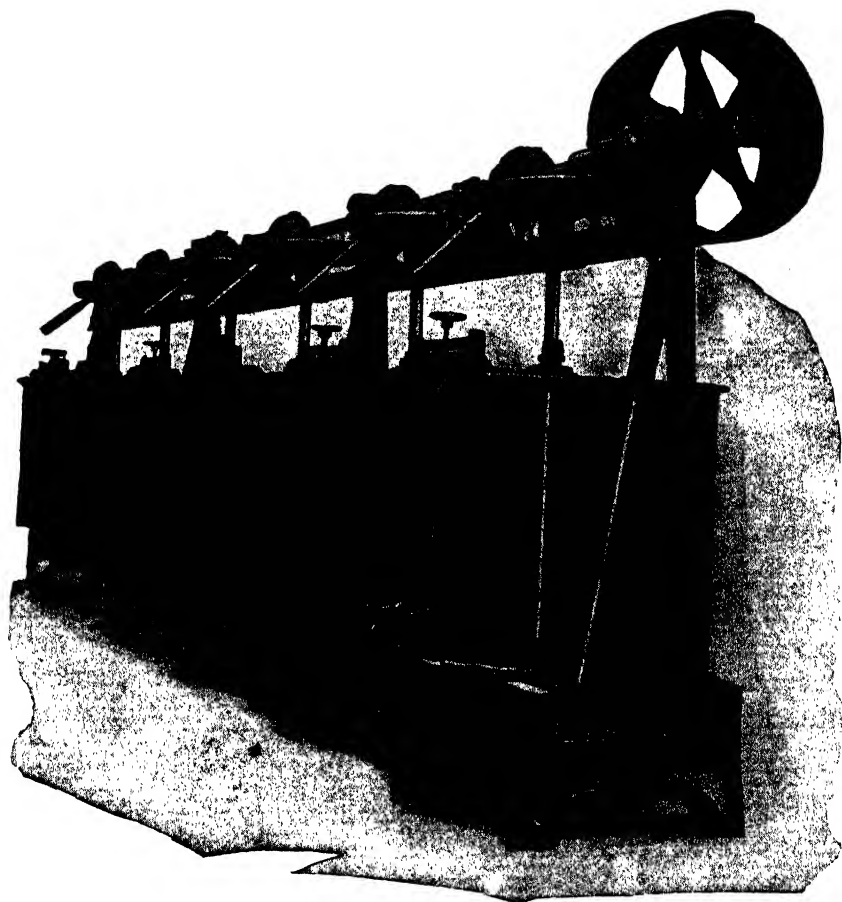


FIG. 6. Battery of mixers

*Kent Machine Wks.*

lacquers (wood lacquers), the type of mixer frequently used is the taller type of tanks equipped with spiral agitation. The turbulent type of agitator for medium viscosity lacquers is frequently used. High speed agitation results in rapid manufacturing and is best



adapted to lacquers of a thin consistency, as stated above, rather than for the pigmented lacquers. High speed type of mixers are also used for dispersing pigments in lacquers without "grinding." Power agita-

tors for agitator drums or barrels are available which will insure more thorough agitation of the lacquer enamel prior to use. This agitation unit is driven by compressed air and may be used constantly at a slow speed or for a short time on a single drum at high speed and then transferred to other drums in stock to prevent hard settling of materials in the bottom of the drums. The portable mixer finds great favor and the propeller blade type is commonly used in the instance of manufacturing lacquers. In this arrangement the tanks are set on skids which are handled with a lift truck.



*Alsop Engineering Corp.*

FIG. 7.  
High speed mixing tank

Shellac cutting tanks are usually of wooden structure and are either of the horizontal or vertical type. (See illustration No. 8.) The turbo mixer which produces high speed agitation is sometimes used. As shellac does not require great agitation (the resin is readily soluble), metal tanks are often used; agitation is rapid and solution withdrawn promptly upon dissolving.

### **Kneading or Mixing Machine**

A machine equipped with spiral blades fitted horizontally is employed. (See illustration No. 9.) Each blade is arranged to move through the path of the other, thereby "kneading" or "shearing" the product. This equipment is used for "dough" type of materials that are used as a colloid on the double rolls, or is often used in the manufacture of paste wood fillers, putty and heavy adhesives. Equipment may be tilted by means of a geared wheel mechanism and material discharged while blades are in motion or discharged by hand. A new vacuum mixer of this type has recently been introduced which finds a suggestive outlet in manufacturing enamels by the "flushed color process."

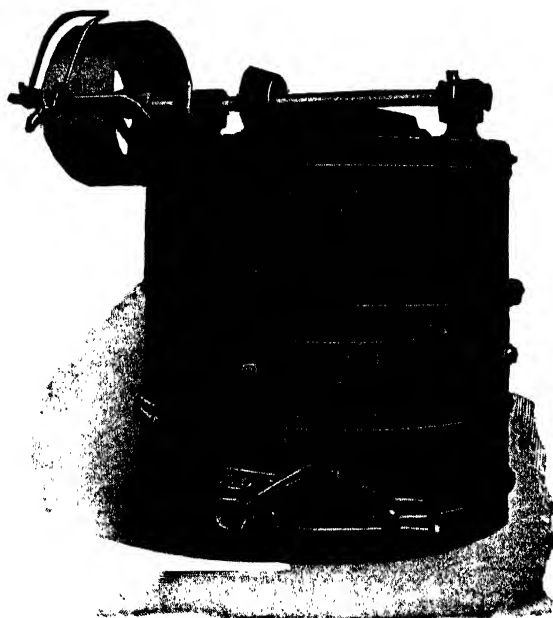


FIG. 8. Shellac cutter *Kent Machine Wks.*

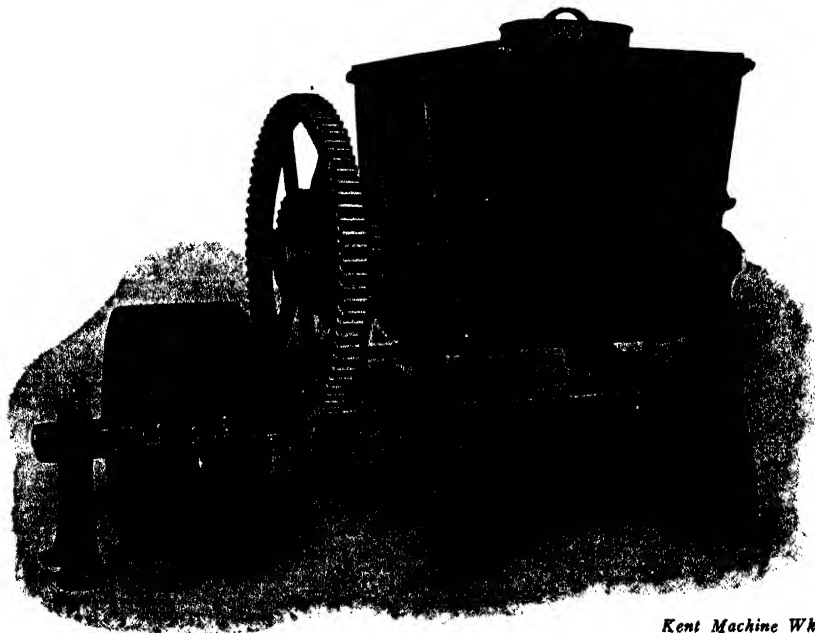
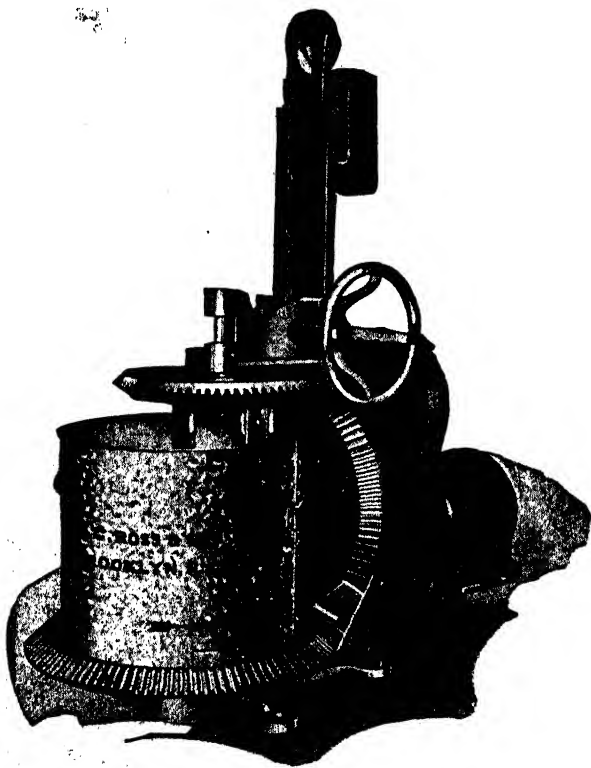


FIG. 9. Kneading machine

*Kent Machine Wks.*

### Change Can Mixer

A change can mixer, as its name would imply, is a stationary four-bladed mixer which allows for the changing of the receptacle or can. That is to say, a change can mixer is used for mixing dry color with grinding vehicles prior to mill grinding and for mixing synthetic enamels prior to mill grinding. The container is placed



*Chas. Ross & Son Co.*

FIG. 10. Change can mixer

on the mixer, and the four blades are inserted into the mixture. The can travels clockwise while the blades travel counterclockwise, resulting in a thorough mixing. The mixer is intended for heavy duty work, mixing is enacted in a quick manner and cans or containers may be changed frequently. (See illustration No. 10.)

### Double Roller Mill

This type of mill is similar to that used in the rubber and plastic industries. In the earlier days of lacquer manufacture, and in some respects the present day, this type of mill was and is used to good advantage in the manufacture of colloidal sheets of lacquer. The



FIG. 11. Two roller mill in operation

structure of the mill involves two hollow steel rollers which rotate horizontally in opposite directions and at different peripheral speeds. Provision is made for the injection of water into one roller and steam into the other. These rollers are of heavy construction which permits

great tension and produces the grinding action of rubbing and crushing the pigment under great pressure. It is usual policy in the manufacture of lacquer on these rollers, to first make what is termed a colloidal base. This necessitates a "dough" or "kneading machine" to produce the amber colored "stock" or base. Dry pigment is added to this base, both being placed between the two rollers (the pigment is first wet with necessary amounts of wetting solvents to overcome the dusting feature and thereby permits the lighter pigment becoming quickly incorporated). Tension between the two rollers is regulated by a hand operated set screw. A finger touch stopping and starting is provided. The sheeting is taken from the front roller and is then dissolved in a mixer with additional solvents and resin solution to a finished product. (See illustration No. 11.)



*J. M. Lehmann Co.*

FIG. 12. Five roller mill

### Three and Five Roller Mill

This equipment is used for pigment grinding of lacquer pastes and pigment grinding of synthetic enamels. The mill comprises

hollow steel rollers which are water cooled. (See illustrations Nos. 12, 13, and 14.)

The pigment is mixed with the vehicle in the change can or pony

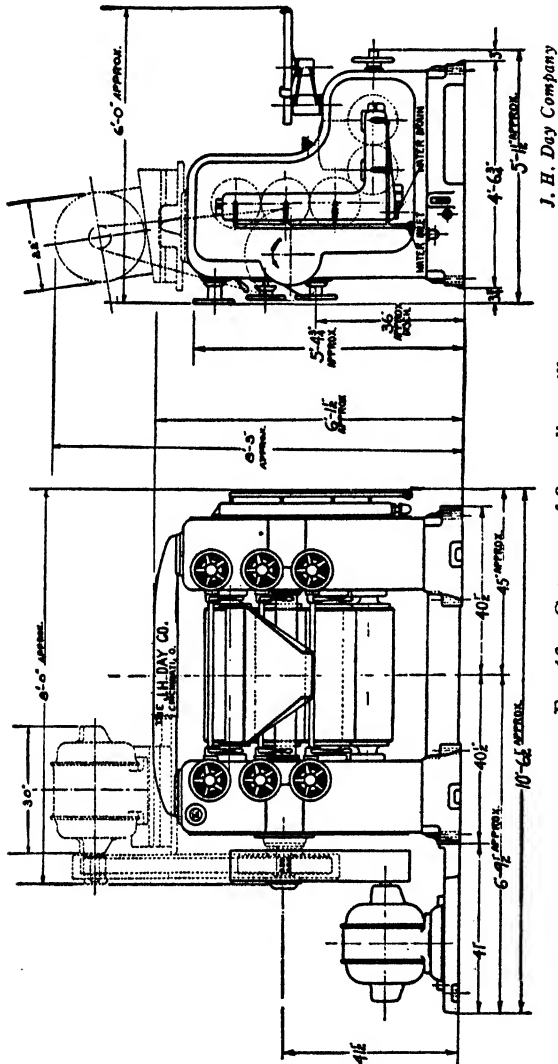


FIG. 13. Cutaway of five roller mill

mixer and is fed between the center and back roller, whence, in its course, it is crushed and ground and is passed over and off the front roller. The rollers are geared to travel at varying speeds, the front

roller being faster than the back roller. As the material passes over the front roller, it is sheared from the roller by a knife and passed down an apron into a receptacle. The number of grinds will vary in accordance with the nature of the pigment and fineness of grind desired. Sweating of certain pigments before grinding is sometimes found necessary. The grinding vehicle relationship to pigment will

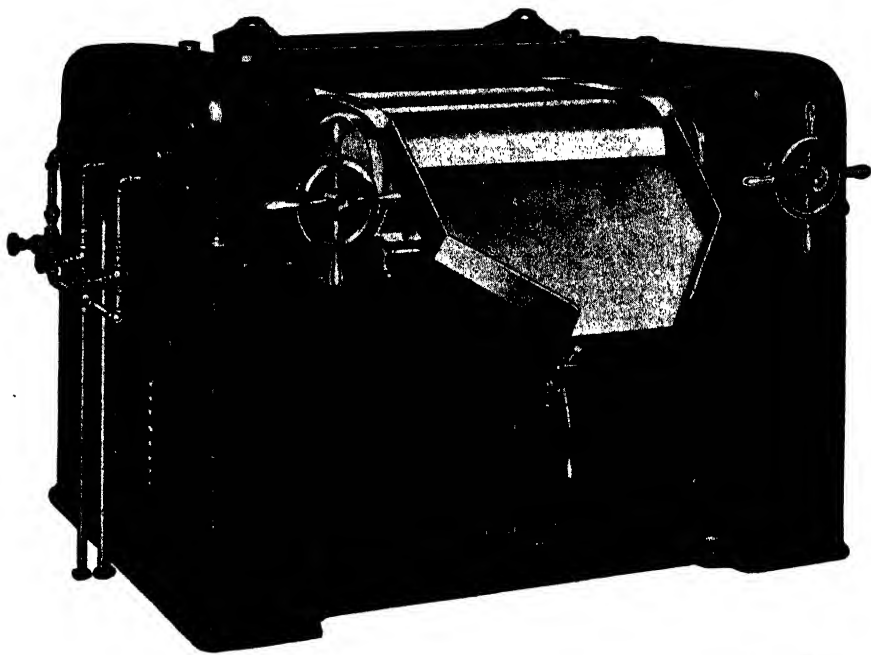


FIG. 14. Three roller mill

*J. H. Day Company*

vary in accordance with the nature of the color and usually requires greater plasticiser additions for lacquer pastes than either stone or pebble mill grinds. The resultant lustre of lacquers involving roller mill ground pigment is higher than other medium or pigment grinds and is believed to be due to better dispersion. Similar to the two roller mill, the action of grinding is by rubbing and crushing under great pressure. Roller mills require greater attention than either stone or pebble mills. The latter requires a minimum, if any, attention as there is no fear of "burning" the pigment. In roller

mill grinding, consideration should be given the fact that the mill surface is entirely exposed and wetting solvents should be selected with great care due to this exposure. Five roller mill grinding equipment is used advantageously for synthetic enamel grinding.

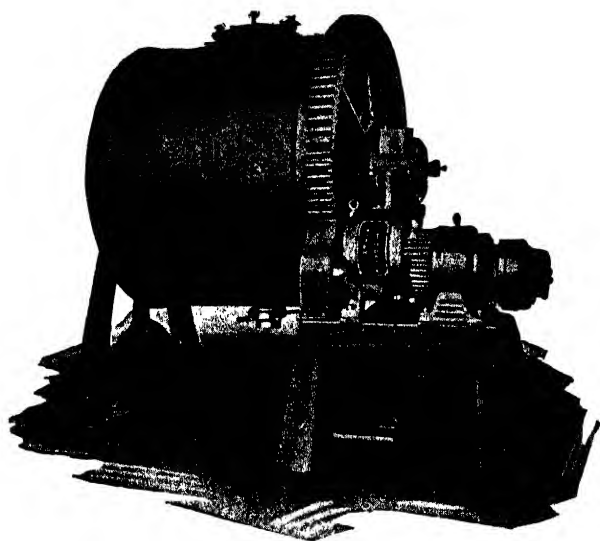
### **Pebble or Ball Mills**

This equipment consists of a cylindrical container or shell of rigid construction. (See illustrations Nos. 15 and 16.) The mill is lined with burr stone (pebble mill) and the grinding action is secured through the presence of grinding bodies in the form of pebbles. Ball mills are unlined and the grinding bodies are steel balls. The mill revolves on an axis which permits of a grinding and crushing action in contact with the pigment. The size of pebbles or steel balls and the consistency of the mill charges have bearing on the degree of fineness of the grind. Grinding vehicles for the pebble or ball mills differ from that of a roller or stone mill charge. There is no evaporation in the closed containers and the determination of a satisfactory grind is by sample tests, until actual grinding hours per type of color are plotted. The mill is equipped with a testing device for drawing samples at the side. The lacquer manufacturer is often bothered with silica in the pebble mill bases and this may be attributed to the presence of grit from the lining of the mill or pebbles, therefore the mill should be properly conditioned before the charge is run. Grinding vehicles for mill bases should include diluent, resin solution, and plasticiser. Pebble mills of laboratory size find great favor for test purposes and may be secured singly or in a battery of two or four.

### **Stone Mills**

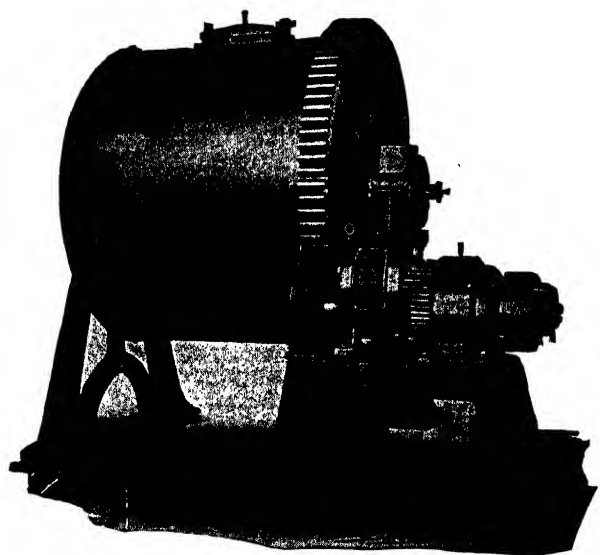
The use of stone mills as a medium of pigment grinding has been well established by the paint manufacturer. Grinding vehicles of relatively non-drying nature must be employed. With the advent of paste grinds for use in lacquer, such problems as (a) volatility of lacquer solvents and (b) satisfactory grinding vehicles, were met and today satisfactory pastes are ground on the stone mills. The stones should be "dressed" in the proper manner for lacquer paste grinding to attain the best results. Three or more grinds are neces-





*Patterson Fdry. & Mach. Co.*

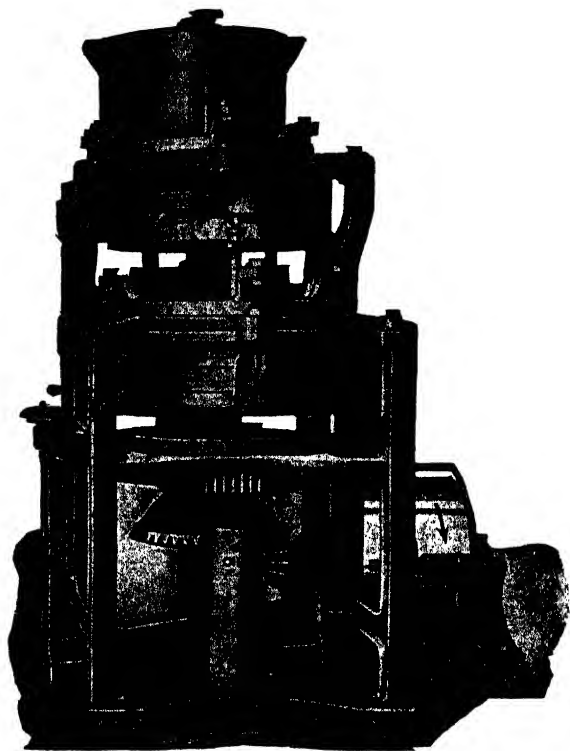
FIG. 15. Ball mill



*Patterson Fdry. & Mach. Co.*

FIG. 16. Ball mill

sary on the harder type of pigments, and sometimes tandem mills which permit a continuous grinding procedure are used. Stone mills are very handy equipment for laboratory test purposes and may be secured and arranged singly or in series. (See illustration No. 17.)



*Chas. Ross & Son Co.*

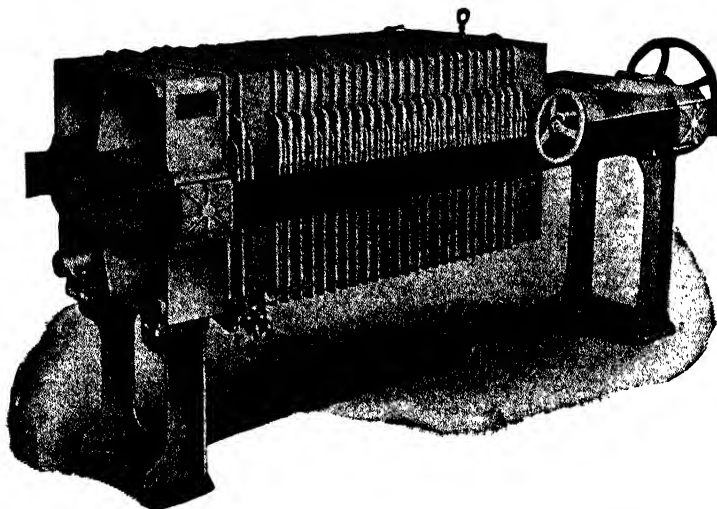
FIG. 17. Stone mill

### Colloid Mills

Colloid mills are more widely used today because of the advancements due to consistent study of particle size of solids and its relation to dispersion. The working principle is that of a hydraulic shearing action produced in a very thin film of liquid. A rotor, running at high speed, and a stator which is stationary are walled forces between which the liquid is drawn. Dispersion is enacted by the principle of high speed agitation (3000 to 17,000 R.P.M.).

**Filtration — Clarification; Filter Presses, Plate and Frame Type**

A flush plate and frame type of filter press is used in the industry. (See illustration No. 18.) These frames are cast with solid webs and thereby reduce the holding capacity of the press without reducing the filtering area. Special cloths and filter paper are employed, the filter paper acting as the true filtering medium. These presses require pressure to force the lacquer through the many cloth and paper



*T. Shriver & Co.*

FIG. 18. Filter press

frames. Force of the pressure pump in driving liquid through the press is likely to rupture the wetted filters and in order to obviate this, heavy canvas cloth may be placed between the filter blocks. The heavier the solution, the greater the pressure required.

The rate of filtration is proportional to the viscosity of the material being filtered and depends largely upon the amount of solid matter in the solution. As the material is forced into the press, saturation of the cloth and paper takes place, therefore filtration is comparatively a slow process. As filtration proceeds, the pressure increases and the rate of filtration decreases. When filtration has been completed, lacquer solvents are pumped through the filtering line into and through the press to prevent the line from clogging, and the

cloth, paper, and frames from hardening. The press may be further utilized for another run following, or may be torn down, filter papers removed, refitted and a new charge run. These filter presses are of the closed delivery type and completed with specially designed

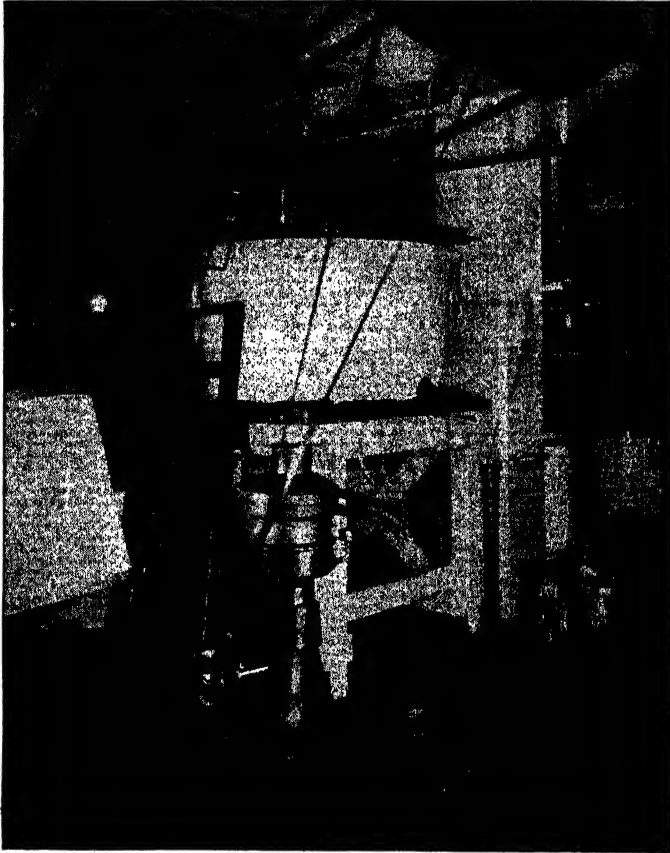


FIG. 19. Clarifier *DeLaval Separator Co.*

pumps. Material may be delivered, without exposure, directly into storage tanks. Colored lacquers are satisfactorily handled in the same manner; however, coarser paper should be used.

### Clarifiers

Clarifiers are constructed of a hollow bowl or metal shell which may travel at five to fifteen thousand R.P.M. (See illustrations Nos.

19, 20, and 21.) This type of filtration is most effective for the low and medium viscosity lacquers. The economy of operation favors the use of clarifiers as does the speed of filtration. The clarification of nitrocellulose lacquers should always be carried out at room tem-

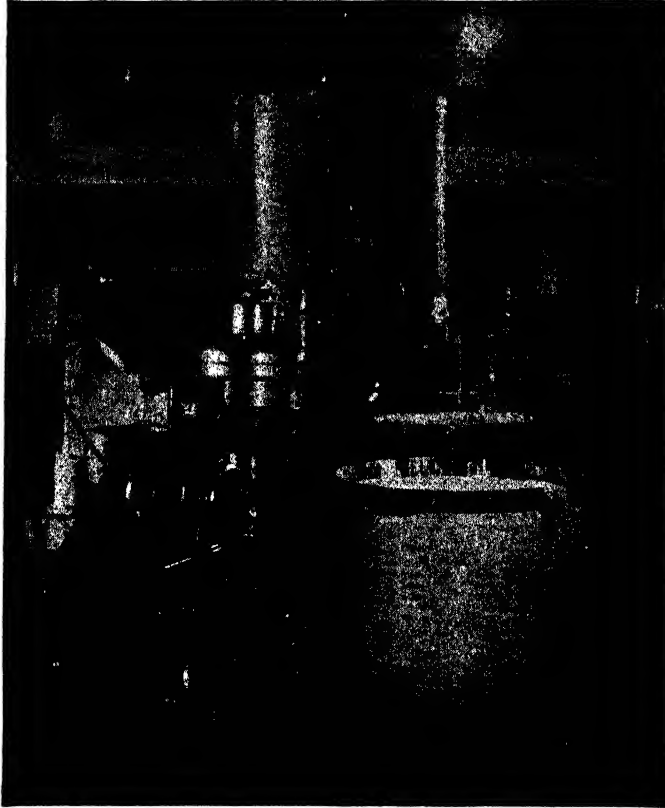


FIG. 20. Clarifier

*DeLaval Separator Co.*

perature. The advantage in favor of clarifiers is through greater speed, less labor, etc. In cases of pigmented lacquers or synthetic enamels, the coarser particles of pigment matter are satisfactorily separated and collected, delivering a finished lacquer or synthetic enamel of a satisfactory nature. Clarifiers may be secured with delivery attachments which produce practically vaportight equipment. Speed of operation may be controlled in view of the type of

material and weight of pigment. This equipment may be of the portable or stationary type.

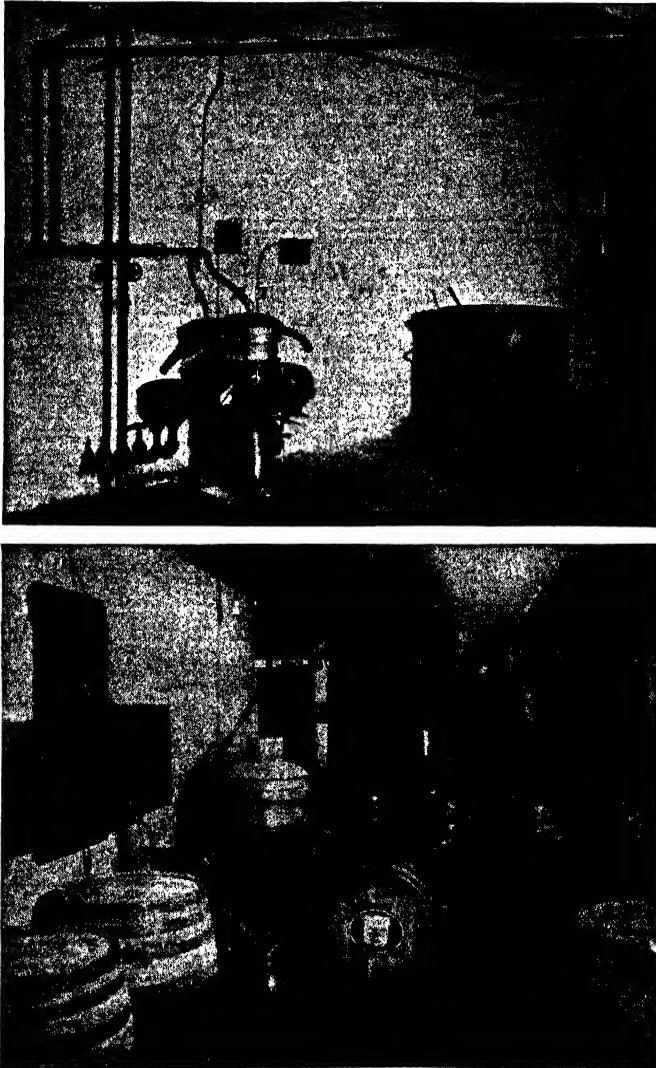
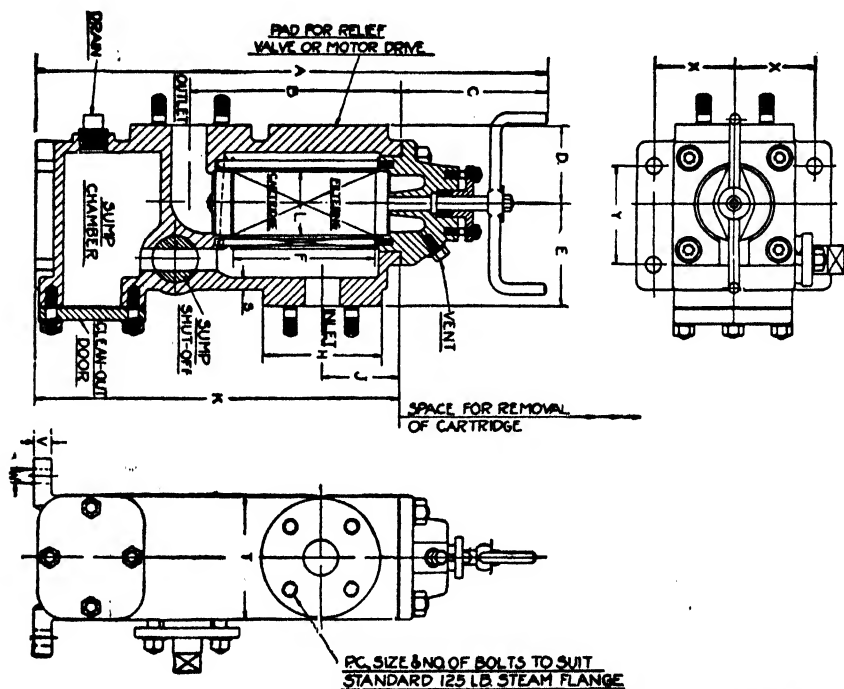


FIG. 21. Clarifier *DeLaval Separator Co.*

A new departure in filtering devices has recently made its appearance on the market. This filter has been used in common practice

on the oil filter lines of motor cars, in oil refineries, etc. It is of simple construction (see illustration No. 22) and is constructed of metal. This filter may be secured on specifications, but for standard practice a type similar to the V.L. type, having a two inch threaded inlet and a one and three-quarter inch outlet is generally used. This filter, operating under low pressure, weighs about eighteen pounds and may be



Cuno Engineering Co.

Fig. 22. Filter press

attached to a five foot pipe length with ell attached direct from stationary tank outlet. The five foot drop from the tank is suitable for pressure. Filter is quite applicable to use with heavy liquids, resin solutions, flat lacquers, synthetic enamels, etc. The filter is composed of shell and filter cartridge, through which the material is passed. The filter does not require any dismantling for cleaning, except when the material to be filtered is changed. A cleaning blade operated on a turn handle is provided so that the particles forced

through the filtering cartridge may be removed from the edge. Such an arrangement does not necessitate the breaking of any joint or interrupting the flow of the liquid. When it is necessary to change the liquid, six threaded bolts are removed at the top and the entire filter may be immersed and saturated in solvent for cleaning.

### Fire Prevention and Protection

In the spray application of lacquers and synthetic enamels, as well as in manufacturing and storage units of finished products and raw materials, the matter of cleanliness and great care in handling should be exercised. The story of protective coatings as presented in the preceding pages is an indication that raw materials are of a flammable nature and their ultimate widespread use may bring about greater fire hazards.

To satisfactorily combat a lacquer fire, there are two methods: one, by cooling the burning material below its ignition point, and the other, by excluding oxygen from the material, thus smothering the fire. This latter has a wider application in fire fighting than the cooling principle. The types of extinguisher devices which are most generally used in the "smothering" principle involve the use of a free gas and the other a "foam." Dry live steam directed at the base of a lacquer fire, having a smothering principle, meets with favor. However, in order to be entirely effective, it necessitates an airtight room, which is almost impracticable in operations. The free gas smothering types are of either carbon tetrachloride base or the liquefied carbon dioxide type and produce a heavy gas which seeks the floor level. These gases dilute the oxygen content of the air adjacent to the fire so that it will not support combustion, and will thereby smother the fire. Fire hazards and correct protection where lacquer is involved are best classified in: (a) lacquer as a liquid, and (b) lacquer as a solid. The first refers to operations, while the second refers to that portion of the liquid atomized in a spray gun and collected on the fan, ducts, and sides of the spray booth. The latter may start from spontaneous combustion more readily than the former. The proper type of extinguisher, correctly placed, properly charged and satisfactorily operated are the four essentials of fire protection. The free gas and foam type of fire extinguisher directed



onto a lacquer fire will not harm the liquid; for this reason, it is more desirable as a combatant against lacquer fires (10).

### Liquefied CO<sub>2</sub> Extinguisher

A portable extinguisher of recent development which has met with great favor is a steel cylinder, fitted with a short hose and having a funnel shaped nozzle. The cylinder is filled with liquefied CO<sub>2</sub> gas

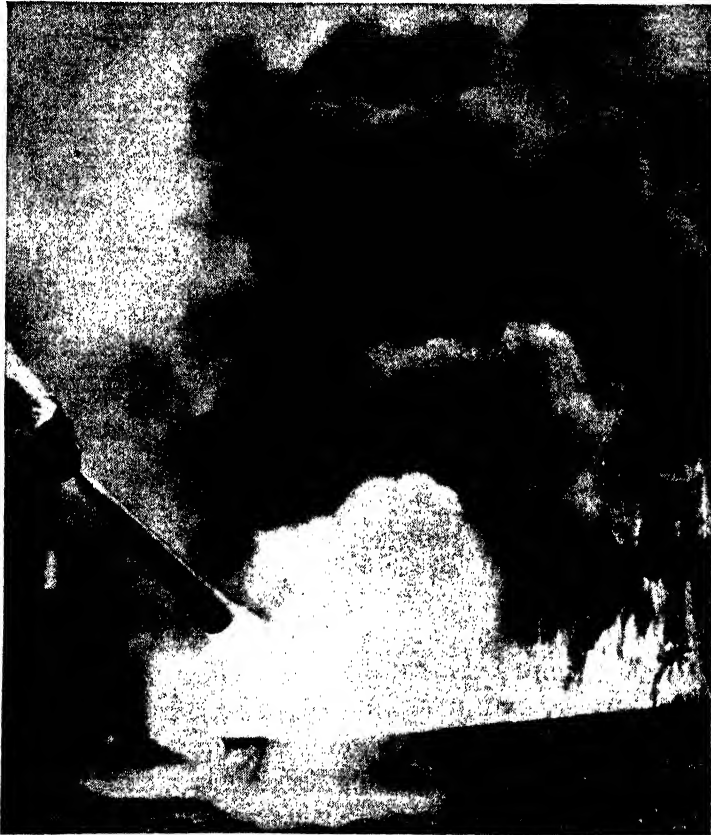


FIG. 23. Fire fighting equipment

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under a great pressure. The extinguisher is operated by a hand valve which releases gas through the nozzle. When the gas is released in contact with the atmosphere, the released gas is chilled and solidifies. This sublimation absorbs heat which snuffs out the fire. This ex-

tinguisher is twofold in effect, namely: by smothering through the  $\text{CO}_2$  gas it discharges and by a cooling effect so produced. (See illustrations Nos. 23 and 24.)

It is urged that the pamphlet "Pyroxylin Finishes, Their Use and Suggestions for Safeguarding the Attendant Hazard" be read by all

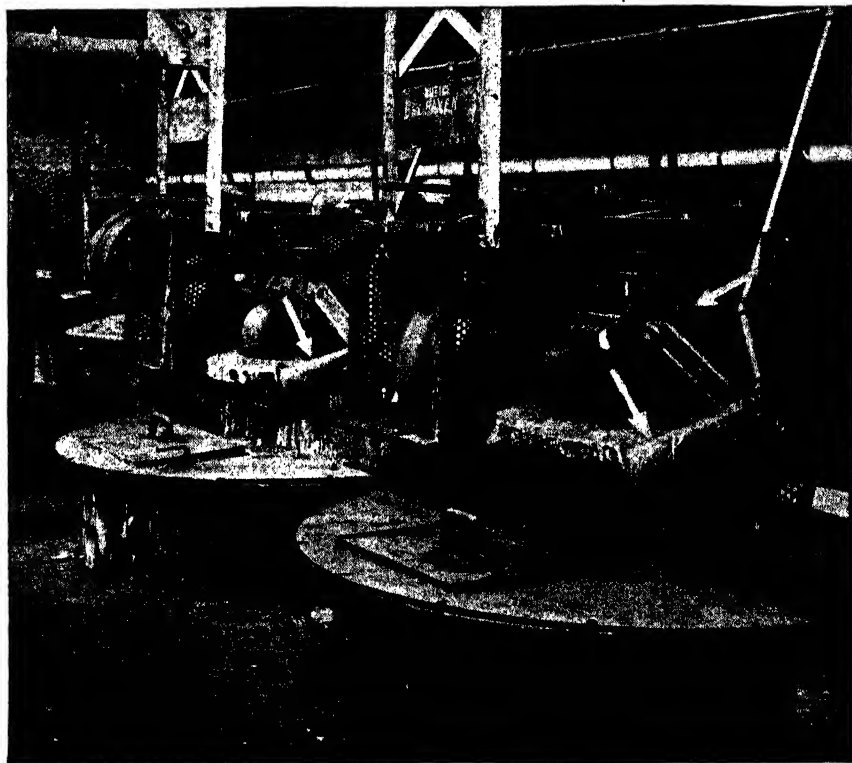


FIG. 24. Fire fighting equipment

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executives as well as by plant employees. This pamphlet is prepared by the committee on manufacturing risks and special hazards, and available through the National Fire Protection Association, 40 Central Street, Boston, Mass. This pamphlet will clearly illustrate the type of fire-fighting unit, location, etc., both for manufacturing units and spray shops.

Satisfactory fire-fighting equipment may be secured through any of the following:

American LaFrance and Foamite Corporation,  
Elmira, New York  
Walter Kidde and Company,  
140 Cedar Street, New York City  
General Carbonic Company,  
New York City.

The suggestions which follow on "Fire Prevention and Protection" were considered standard practice in a large lacquer manufacturing establishment:

#### **FIRE PREVENTION AND PROTECTION SUGGESTIONS**

##### **Handling and Storage of Nitrocellulose, Film Scrap**

1. Nitrocellulose, as it is received by a prospective user, is classified as an inflammable material. It must be remembered that as it is received it is wetted down with approximately 30% alcohol. The term "wetted down" is described in the following manner: "under mechanical pressure during manufacture and preparation prior to shipping, the water is pressed from the cotton fibres and ethyl alcohol is introduced into the fibres of the cotton. The 30% net weight of the barrel's content comprising this alcohol cannot be considered as excessive. The alcohol cannot be squeezed from the nitrocellulose or poured out from the barrel, since the alcohol has been completely absorbed by the nitrocellulose."

About twenty years or so ago, after exhaustive investigation on the part of the Bureau of Explosives, product as described above had been classified as an inflammable material. Prior to that date soluble cotton shipments wet with 20% water had been allowed by the Bureau. With the advent of widespread use of nitrocellulose in the lacquer industry, it was brought out that water was non-compatible with such constituents as may enter into lacquer products. Ethyl alcohol being an extender in lacquers, as well as a gum or resin solvent, was considered and adopted. Because of the low flash point of alcohol, it is considered an inflammable material. Therefore, nitrocellulose wetted with alcohol may be considered in the same category, while if the nitrocellulose were wetted with water it could

not be classified as an inflammable material, but as an inflammable solid.

The containers in which the nitrocellulose is shipped are of the openhead steel barrel variety. These barrels have a well-fitted fibre gasket on the lid, producing a tight closure. These packages will withstand an internal pressure of forty pounds per square inch.

A separate building, magazine or section of yard should be maintained for the storage of these materials. Such a location should be isolated from plant operations. Magazine should be of brick or concrete structure and capable of handling the entire amount of such materials available at the manufacturing unit (see nitrocellulose storage, this chapter). This building should be of low structure, about ten feet high. The drums of nitrocellulose should be stored in a horizontal position (on sides rather than on ends), which will permit a greater distribution of the alcohol throughout the drum's content. If the drums of nitrocellulose, which may constitute the magazine overflow, are stored in the yard, burlap sacks which are frequently wetted with water should be placed over them.

2. Water sprinkler protection should be provided in magazine and storage building.

3. Heat should never be resorted to in magazine where nitrocellulose or film scrap may be stored. If steam heaters are necessarily a part of equipment, the nitrocellulose or scrap film should be kept as far away as possible. Cotton dust should never be permitted to collect on radiators.

4. It is always advisable to use the entire content of a drum of nitrocellulose. Formulas should be based on 164 or 193 pounds and nitrocellulose should be drawn a drum at a time from the magazine or storage or enough for immediate requirements.

5. Drums of nitrocellulose should never be permitted to lie around. Whenever a drum has been emptied, it should be kept in an isolated place until returned. The weighing of nitrocellulose should be segregated from operations.

6. In the event of spillage, the nitrocellulose should be swept up immediately and disposed of properly. The proper disposal of such spillage and floor sweepings should be to place it into a drum of miscellaneous drainings in which they may immediately dissolve.

7. The usual cemented floor space of the magazine as well as loading platform adjacent to the lacquer mixers should be properly protected with non-sparking coverings: linoleum, tar paper, or a heavy molten tar-like preparation which may be poured onto the metal flooring and allowed to dry. Breaks appearing in such coatings should be remolded.

8. Brass or phosphorous bronze tools should always be used in the lacquer factory and wrenches of this nature are provided for use in opening nitrocellulose drums.

9. When nitrocellulose is received in carload consignments, the individual drums should be slid down an incline head-up and the slide insured free of nails driven where the drum may contact. Likewise if there are free particles of nitrocellulose lying around the car, they should be swept up and disposed of.

### Handling and Storage of Solvents

1. Storage tanks or drum containers should be isolated from manufacturing operations. Wherever possible volume storage should be maintained in either a buried or elevated tank.

2. An adequate pumping system should be employed for the transferring of solvents from or to such storage tanks.

3. The venting system on all storage tanks should be properly protected with brass wire screening and should likewise be of a sufficient height to protrude well over the roof of buildings if they are located adjacent to such tanks.

4. Glass gauges on storage tanks above ground should be avoided, as in time of fire they are subjected to breakage and spouting burning liquid.

5. Elevated tanks should be properly grounded as a protection against static electricity and lightning.

6. Elevated tanks should likewise be provided with adequate pits of concrete foundation surrounding the tank and of sufficient size to measure the capacity of the tank, which will prevent the spread of inflammable solvent in the event of a fire. A sizeable placard "FLAMMABLE — KEEP FIRE AWAY" should also be properly exposed.

7. When transferring solvent into storage tanks it should always be pumped or siphoned. Dumping should always be avoided as this

will allow the spread of solvent vapors. Low boiling, low flash point solvent vapors may form with air and result in an explosive mixture which may be ignited with an open flame or sparks from an electric motor.

8. Solvent lines used to transfer liquids from the storage tanks to plant operations should always be emptied after use, both from the standpoint of presented fire hazard and insurance of a free line in the event of a change in material going over the same line. Lines leading into stationary mixing tanks should be tapered to a flow-back point where the line may be satisfactorily drained to thoroughly insure freeness of solvent.

### **Machinery and Electrical Equipment**

1. The use of self-oiling bearings is advocated.

2. Wooden pulleys, which present a fire hazard through belt friction in the event of an overload and the increased difficulty of removing static electricity through the insulating effect of the pulleys, should be avoided. Chain drives or herringbone gears have been found to give very satisfactory results.

3. Overheating or sparks due to machinery parts friction should be continuously guarded against. Such parts should be well oiled and grease cups should be kept filled constantly.

4. All motors should be placed outside buildings in which solvents are stored or used. This likewise refers to all power and light switches.

5. The use of electric portable extensions, cord lamps, etc., should be prohibited.

6. Vaporproof globes should be placed around all electric lights.

7. Conduit wiring and satisfactory gaskets to insure tightness should be provided.

8. All electric motor frames, switching cases, etc., should be effectively grounded in at least two places by the loop system of grounding.

9. Through the use of the herringbone gear system, a shafting may be introduced from the motor which is placed outside the manufacturing building. Motors are placed on a shelf, and through a flexible gasket which joins the shafting, may satisfactorily run a battery of stationary mixers. This flexible gasket will take up any "off center" or variation of the shafting.

## Venting and Ventilating

1. Wherever possible stationary mixers should be constructed with stationary covers. In reality the top cover section of the tank should be a part of the tank itself and should be tightly welded. Material introduced into such a container, other than through pipe line for solvents should involve a minimum sized manhole cover. This cover should have a satisfactory lip with handle arrangement and the lip should fit loosely into a double edge receiver. This receiver may then be filled with solvent or thin lacquer solution, thereby permitting an absolutely airtight tank.

2. Stationary tanks, mixers, etc., should be properly connected to vent pipe arrangement.

3. Proper metal ventilating stacks should be provided. Such stacks should be vertical and brought down to about the floor level. All vent pipe equipment should extend to a point at least five feet higher than the roof top.

## Heating

1. Steam pipes should be eliminated in lacquer manufacturing units; especially is this true in magazines and such building space given over to the storage of nitrocellulose.

2. If heating is necessary, the indirect heating system is perhaps the best. The air taken into the system should enter the duct at a safe distance to entirely exclude the contamination of vapors and flammable dust. The hot air ducts should be so designed that fire may not follow possible solvent vapors through it from one point to another when the system may be in operation.

## Static Electricity

1. This subject is described under Machinery and Electrical Equipment. A loop system of grounding should be resorted to. Each piece of apparatus for grounding is connected separately and ground looped in at least two places; a series of ground connections is not advocated.

2. While the lubricating oil in which a revolving shaft is being run will offer resistance to the possible passage of static electricity from shafts to bearings, the revolving shaft should be properly

grounded through copper gauze spring contact brushes rubbing against the shaft in much the same manner as brushes on motor commutators.

3. Static electricity, generated by friction within the tank by a stream of solvent or in filling smaller containers from drums, may cause sparks which may ignite the liquid. Such containers should be satisfactorily grounded. A very disastrous fire and explosion occurred in a large Detroit automobile establishment in April, 1927. An investigation concluded that the fire and/or explosion originated either inside the auxiliary box, around a mercury vapor electric lamp or from the ignition of the vaporized lacquer by static electricity.

### **Tools and Appliances**

1. As described under the heading of Nitrocellulose, brass tools should be employed.

2. Electrical extensions should not be used inside large stationary tanks.

3. Any repairs necessitating the use of portable equipment of this nature should be investigated and preparations made in advance so that the use of such equipment will not present a hazard.

4. Chain hoists and hand trucks should not be used in operating buildings. The hand truck, if found to be necessary, should have wheels of non-sparking composition.

5. Leaky drums should never be repaired before they have been first filled with water or filled with live steam to remove solvent or vapors.

### **Egress Facilities**

1. A building given over to the manufacture of lacquer should be free of all possible blind spots.

2. Drums and storage, if found necessary in an operating unit, should be placed free of the exits.

3. The doors should not be latched with anything other than light material so that with minimum exertion of pressure they will release the holding. If a manufacturing unit entails more than a single story, an escape hatch in the form of a chute should be located at the door



exit, this chute to be as wide as the door itself and the door always to open outward and with the least pressure.

### Housekeeping

1. In the foregoing suggestions it has been brought out that excessive quantities of flammable materials should be kept down to a minimum; this will minimize fire risks.

2. Metallic containers, metal machinery and wooden boxes with nails should not be drawn over a concrete floor.

3. All inflammable materials, such as wooden cases, filtering cloths, and wiping rags, should be placed in a specially constructed metal container filled with water, while stored in an operating building. Whenever possible this accumulation should be removed and burned.

4. Standard samples and maintained production samples should be kept in a separate building away from operations; this likewise refers to overproduction from batches.

5. Experimental and research work should be confined to the laboratory.

6. Lacquer coated clothing worn by the operators should be changed frequently, as possible frictional rubbing exposes them to serious dangers.

7. Stationary machinery and interior walls should be finished in white or light color. This will serve to increase efficiency of illumination and encourage good housekeeping.

8. The greatest care should be exercised in the spray gun application of lacquer materials. Dust is a menace to industrial plants, and some disastrous fires have been attributed to unsatisfactory methods of housekeeping.

9. The spray application of lacquer involves the breaking-up or atomizing of liquids into very finely divided particles. In this application the entire width evolved or thrown off by the various spray gun nozzles under air pressure cannot be confined to the surface being coated. The excess is drawn off through an exhaust fan. Some particles of the atomized lacquer, therefore, become attached to the sides of the spray booth and fans. It is this dust which is a menace, as possible contact with unprotected light extensions or through spontaneous combustion may cause a disastrous fire or explosion.

10. It is considered good practice to line the inner chamber of the spray booth with either heavy oil, which is of non-drying nature, with paper, or through the use of a special water soluble coating. The oil collects the atomized lacquer and may be wiped free of the surface at will, while the booth may be stripped and repapered. The booth coating may be washed free with a stream of water and should be done at least once each week. The use of "water spray booths" is advocated.

### **Fire-Fighting Equipment and Organization**

1. Automatic sprinklers are desirable in certain places; however, their fire protection value should be balanced against possible water damage and possibility of spreading solvent fires.

2. The foam type of extinguisher is valuable and very effective. Small hand extinguishers of this type should be available and handily located throughout the unit. This foam type of extinguisher is  $\text{CO}_2$  which is liquefied under pressure. This dry carbonic snow, as it becomes, is lighter than the burning liquid and completely blankets the burning surface which prevents the spreading of the flame or possible reflashing. Water and ordinary extinguisher liquids being heavier than the liquids themselves go quickly to the bottom, thereby overflowing the liquid and spreading the fire.

3. Live dry steam is also a very effective medium used in extinguishing solvent vapor fires. A water bleeding valve should insure absolute freedom of water in entering through the many valve jets. This line should be constantly drained of water. A two inch main line should be located at a strategic point with a gate valve release. From this point the line may be tapered to one half inch lines leading into the unit and located in series both at the floor base and midway up the side of the building.

4. All exits and windows should be so arranged that they may be satisfactorily and quickly closed, or arranged so they will automatically close in the event of a fire. If skylight ventilating is used, it should be constructed on an endless chain device out of doors that they may be freely and quickly closed. In the event of a fire flash, the doors and such exits are closed tightly and the steam valve is turned on, the steam having a smothering action on the fire. A well-organized

fire-fighting unit composed of plant operators is always desirable. Fire drills should be called at unexpected times and the men instructed in ways and means of fighting such fires.

### Fire-Fighting Dangers

1. The two principal dangers present are: explosions of apparatus and nitrous oxide fumes from burning lacquer or nitrocellulose.

2. An extract from the chemical section of the Fourteenth Safety Congress, which refers to such dangers, and covering the medical treatment is quoted: " The active principle of nitrous fumes is NOT an acid gas. When it is first inhaled this gas causes coughing, a choking sensation, pain in the chest, and the expectoration of a yellow tinged sputum. If the exposure ceases, the symptoms subside and the person who has been exposed to the fumes often feels strong enough to walk several miles to his home, and suddenly he exhibits formulation symptoms of respiratory disease with progressive edema of the lungs and within a few hours he is dead. Some cases recover from the initial edema only to develop pneumonia within twenty-four to thirty-six hours; many of the pneumonia cases dying, some recover. After the edema sets in there is almost nothing one can do in the way of treatment and the outcome is simply a question of individual resistance, but if the condition is recognized at the start and chemical common sense is applied, the victim of nitrous fume poisoning can be saved in every instance. The present medical treatment for nitrous fume poisoning as given in books on the subject, i.e., the inhalator and oxygen, is absolutely futile. What is needed is something to stop at once the action of nitric and nitrous acid which is formed in the mucous membrane and the respiratory tract. There is only one agent that will do this, namely AMMONIA GAS. Use an inhalator if you wish, but be certain to have the air which is taken into the lungs bubble through a dilute solution of AMMONIUM HYDRATE. However, the simplest and best method is to hold a pepper shaker filled with lumps of AMMONIUM CARBONATE to the victim's nose and make him deeply inhale the escaping ammonia gas. The latter immediately neutralizes the acid with the formation of harmless ammonium nitrate and nitrite."

Sufficient amounts of AMMONIUM CARBONATE should be

strategically located around the manufacturing unit. This salt should be placed in a wide mouthed reagent bottle, which in turn may be kept in a fibre box with an airtight cover and conspicuously marked. Complete instructions for use should likewise be given the operators.

### First Aid

In May, 1929, a fire and explosion killed many people in a Cleveland clinic disaster. The fire and explosion was attributed to nitrocellulose films. Many deaths were caused by nitrous fumes. The following is a quotation from one of the journals which covered this disaster: "One peculiarity of the fumes, over the identity of which there was some uncertainty at first, was that they killed some instantly, while others who breathed them felt at first no ill effects but died later and almost without warning. The victims were literally drowned by the fumes, composed of nitrogen dioxide, known also as nitrogen peroxide and nitrous fumes. Nitrogen dioxide is the most insidious, irritant gas known. A workman who has been exposed to the action of nitrous fumes as the result of a slight industrial mishap may barely be inconvenienced at the time and may go home hardly thinking of the incident, and yet during the night edema of the lungs develops. Edema is the presence of abnormal amounts of liquid. This edema of the lungs is in these cases so severe that the patient frequently dies before morning or during the following day, hardly twenty-four hours after the accident. The cause of the death is literally drowning of the lungs in the great volume of liquid poured out in them.

"Nitrogen peroxide is produced to a small extent during the explosion of certain compounds, but is produced in much greater quantities when the substance is burned. The burning of ordinary celluloid or celluloid stone, of guncotton, of dynamite, and similar substances produces large amounts of this deadly substance.

"The action of the nitrogen peroxide is generally not due to its systemic effect. The inhalation of the gas leads, it is true, to dilation of the arteries, fall in blood pressure, vertigo, headaches and the alteration of the hemoglobin of the blood to methemoglobin, but this action seldom plays an important part in poisoning by the fumes, because the irritation which is produced in the respiratory tract is so intense that it overshadows the systemic effect. The direct result of

.....

this irritating action is an inflammation of the lungs, leading to the pulmonary edema. The epithelium or cellular covering of the finer air tracts in the lungs is damaged, and fluid escapes from the capillaries and accumulates between the cells. Within a few seconds after the inhalation of this gas, the fumes have stifled the ability to cry out. A fit of coughing, then unconsciousness, and then death."

Smoking should be strictly prohibited in and near all operating units. The carrying of matches should likewise be prohibited. Frequent match searches should be conducted.

#### REFERENCE

(10) See Pamphlet entitled, "Pyroxylin Lacquer Manufacture," by the National Safety Council, Inc., 20 North Wacker Drive, Chicago, Ill.

## REQUIREMENTS · TYPES FORMULATION

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The perfection of lacquer has brought about a rapid replacement of paint, varnish, etc., and prompted such manufacturers to enter the lacquer field. Many such manufacturers lacked the services of technicians, proper means of laboratory control and service men schooled in the handling of lacquer products.

The individual requirements of a given lacquer, synthetic enamel, or similar material is influenced by the formulation (selection of raw materials), use to which it is put and method of application. The formulation of any given coating material is an art, and properly formulated and properly applied coatings will last for an indefinite period of time.

It is the function of a lacquer, as applied to a given object and over a properly prepared surface, to preserve and to beautify. The lacquer must be durable, which has bearing on its proper formulation, and the finish must be preserved in consideration of the type and surface to which it is applied. The finish should be made one of the strongest talking points, inasmuch as it is the appearance of any finished product which markedly influences its sale.

The statement has been made that a lacquer or similar material is no stronger than its weakest link — if one coat fails the entire finish fails. This true statement is influenced by such factors as formulation, methods of application, type of equipment for application, conditions under which it is applied, and man power. A good finish can redeem a poor design or faulty surface, but a poor finish cannot be hidden.

Lacquer coatings, due to their rapid drying features, do not collect dust as readily as other finishes, and therefore, require less frequent cleaning. A lacquered surface is resistant to the action of water and soap; therefore, no special cleaning preparation is required. In fact alkaline solutions often tend to preserve the appearance of a lacquered surface.

It is a point worthy of remention that lacquers will outlive the average paint job. Oil paints and varnishes live only as long as they may consume oxygen; they are phenomena of combustion. As such varnishes dry, they increase in weight because of consumed oxygen; conversely lacquers decrease in volume. The wearing and resisting quality of lacquer depends on application, equipment, surface, and care after it is in use. It has long been the aim of the lacquer chemist to secure the building properties of varnish with the rapid drying feature as presented by lacquer. This aim has been reached (or nearly so) through the use of synthetic resin as a replacement for fossil resin in the structure of the lacquer.

Factors essential to satisfactory lacquer finishes are:

1. Clean surfaces, free of dust, grease and all foreign materials.
2. Properly formulated, in consideration of:
  - (a) flexibility
  - (b) glossy but not brittle
  - (c) stand buffing
  - (d) stand a certain degree of heat
  - (e) free of orange peel
  - (f) application over paint undercoats
  - (g) enamels should show proper dispersion of pigments to eliminate "settling," after flocculation, etc.
  - (h) ease of application
  - (i) free of objectionable and toxic odors
  - (j) not too expensive
  - (k) must be durable
3. Satisfactory method of application.

Briefly stated, a lacquer may be constructed for application and use on any surface that requires coating for protective or decorative purposes.

The following is a part alphabetical list of various types of finishes:

|                                |                          |                             |
|--------------------------------|--------------------------|-----------------------------|
| <i>Acetate</i>                 | <i>candlestick</i>       | <i>fender</i>               |
| <i>acetate dopes</i>           | <i>carbon black</i>      | <i>fillers (wood-metal)</i> |
| <i>acid resisting</i>          | <i>carburetor</i>        | <i>finishing</i>            |
| <i>adhesives</i>               | <i>cartridge</i>         | <i>fibre</i>                |
| <i>aircraft</i>                | <i>casket</i>            | <i>fixture</i>              |
| <i>airship dopes</i>           | <i>cedar chest</i>       | <i>film</i>                 |
| <i>alcohol proof</i>           | <i>cements</i>           | <i>flexible</i>             |
| <i>amalgamators</i>            | <i>celluloid article</i> | <i>fish line</i>            |
| <i>aluminum</i>                | <i>ceramic</i>           | <i>floco</i>                |
| <i>alkali resisting</i>        | <i>chair</i>             | <i>flesh enamels</i>        |
| <i>automotive</i>              | <i>chandelier</i>        | <i>floor</i>                |
| <i>antiquing</i>               | <i>chassis</i>           | <i>furniture</i>            |
| <i>amyl acetate solutions</i>  | <i>chromium</i>          | <i>flat</i>                 |
| <i>architectural</i>           | <i>clear</i>             | <i>Gasket</i>               |
| <i>art novelty</i>             | <i>clear wood</i>        | <i>gas tank</i>             |
| <i>artificial flower</i>       | <i>cloth</i>             | <i>glass</i>                |
| <i>Baby carriage</i>           | <i>coffin</i>            | <i>gasoline resisting</i>   |
| <i>baking</i>                  | <i>colored</i>           | <i>gold</i>                 |
| <i>ballon dopes</i>            | <i>copper</i>            | <i>gold leaf</i>            |
| <i>base</i>                    | <i>compartment</i>       | <i>golf ball</i>            |
| <i>basket</i>                  | <i>cosmetic</i>          | <i>golf club</i>            |
| <i>belting cements</i>         | <i>cotton</i>            | <i>graining</i>             |
| <i>black</i>                   | <i>crackle</i>           | <i>grease resisting</i>     |
| <i>bleaching</i>               | <i>crank case</i>        | <i>ground coat</i>          |
| <i>blocking</i>                | <i>crystallizing</i>     | <i>gum</i>                  |
| <i>blush resisting</i>         | <i>Decalcomania</i>      | <i>gun metal</i>            |
| <i>boat</i>                    | <i>desk</i>              | <i>gun sheen</i>            |
| <i>bond coat</i>               | <i>dipping</i>           | <i>Heat resisting</i>       |
| <i>bookbinding</i>             | <i>doll</i>              | <i>hair</i>                 |
| <i>brewery</i>                 | <i>dope</i>              | <i>hairpin</i>              |
| <i>bronzing</i>                | <i>drum</i>              | <i>handle</i>               |
| <i>brass</i>                   | <i>drawer coater</i>     | <i>hat</i>                  |
| <i>bronzing liquids</i>        | <i>dull</i>              | <i>headlight</i>            |
| <i>broom handle</i>            | <i>dye</i>               | <i>heater</i>               |
| <i>brushing</i>                | <i>dress finding</i>     | <i>heel</i>                 |
| <i>bedstead</i>                | <i>Eggshell</i>          | <i>high solid</i>           |
| <i>building coat</i>           | <i>embossing</i>         | <i>hospital</i>             |
| <i>burial case</i>             | <i>etching</i>           | <i>heat-reactive</i>        |
| <i>burial vault</i>            | <i>electric goods</i>    | <i>Imprint coater</i>       |
| <i>button</i>                  | <i>engraving</i>         | <i>insulating</i>           |
| <i>butyl acetate solutions</i> | <i>engine</i>            | <i>ink</i>                  |
| <i>Cabinet</i>                 | <i>emulsion</i>          | <i>imitation tile</i>       |
| <i>cable</i>                   | <i>enamels</i>           | <i>interior</i>             |
| <i>cadmium</i>                 | <i>Fabric</i>            | <i>iron</i>                 |
| <i>camera</i>                  | <i>false body</i>        | <i>intermediate</i>         |
| <i>can</i>                     | <i>feather</i>           | <i>iron filler</i>          |



|                           |                             |                               |
|---------------------------|-----------------------------|-------------------------------|
| <i>iridescent</i>         | <i>outdoor</i>              | <i>spraying</i>               |
| <i>Jewelry</i>            | <i>optical instrument</i>   | <i>squeegee</i>               |
| <i>Knifing undercoat</i>  | <i>Paper</i>                | <i>stain</i>                  |
| <i>Label varnish</i>      | <i>parchment</i>            | <i>steam resisting</i>        |
| <i>lace</i>               | <i>pastes</i>               | <i>stencil</i>                |
| <i>lamp</i>               | <i>paste wood fillers</i>   | <i>steering wheel</i>         |
| <i>laundry</i>            | <i>pearl</i>                | <i>stippling</i>              |
| <i>leather dope</i>       | <i>piano</i>                | <i>stop-off</i>               |
| <i>leather</i>            | <i>pigmented</i>            | <i>stove</i>                  |
| <i>license plate</i>      | <i>pencil</i>               | <i>street car</i>             |
| <i>line</i>               | <i>picture frame</i>        | <i>striping</i>               |
| <i>light bulb</i>         | <i>pipe</i>                 | <i>street marking</i>         |
| <i>lighting fixture</i>   | <i>plaster of paris</i>     | <i>stripping</i>              |
| <i>linoleum</i>           | <i>polishing</i>            | <i>surfacer</i>               |
| <i>machinery</i>          | <i>pottery</i>              | <i>synthetic lacquers and</i> |
| <i>mantle dip</i>         | <i>primer</i>               | <i>synthetic enamels</i>      |
| <i>map</i>                | <i>primer-surfacer</i>      | <i>Tank</i>                   |
| <i>marbleizing</i>        | <i>processing</i>           | <i>toe</i>                    |
| <i>mat</i>                | <i>pump</i>                 | <i>textile</i>                |
| <i>metal</i>              | <i>putty</i>                | <i>tin</i>                    |
| <i>mirror</i>             | <i>pyroxylin</i>            | <i>tin foil</i>               |
| <i>mist coat</i>          | <i>Radio case</i>           | <i>tinting</i>                |
| <i>mixing</i>             | <i>railway</i>              | <i>tile</i>                   |
| <i>mother of pearl</i>    | <i>raincoat</i>             | <i>tire</i>                   |
| <i>motor boat</i>         | <i>razor</i>                | <i>tire cover</i>             |
| <i>motor car</i>          | <i>reflector</i>            | <i>toning</i>                 |
| <i>Mottled effect</i>     | <i>refrigerator</i>         | <i>toilet seat</i>            |
| <i>molding</i>            | <i>roller coating</i>       | <i>tool</i>                   |
| <i>marproof</i>           | <i>rubber</i>               | <i>top coat</i>               |
| <i>musical instrument</i> | <i>rubbing</i>              | <i>touch up</i>               |
| <i>Nail polish</i>        | <i>retarder</i>             | <i>toy</i>                    |
| <i>nitrate dope</i>       | <i>resin</i>                | <i>traffic</i>                |
| <i>nitrate</i>            | <i>Sanding</i>              | <i>tracing cloth</i>          |
| <i>nitrocellulose</i>     | <i>sanitary</i>             | <i>transparent</i>            |
| <i>non-bleeding</i>       | <i>sealers</i>              | <i>truck</i>                  |
| <i>non-chalking</i>       | <i>sealing</i>              | <i>trunk</i>                  |
| <i>non-fading</i>         | <i>semi-pigmented dopes</i> | <i>tumbling</i>               |
| <i>non-flammable</i>      | <i>shaping</i>              | <i>tube (paper)</i>           |
| <i>non-lifting</i>        | <i>shellac</i>              | <i>typewriter</i>             |
| <i>non-raising</i>        | <i>shellac substitute</i>   | <i>Umbrella</i>               |
| <i>non-staining</i>       | <i>shingle</i>              | <i>undercoat</i>              |
| <i>non-spotting</i>       | <i>shoe</i>                 | <i>Varnish</i>                |
| <i>non-yellowing</i>      | <i>sign</i>                 | <i>veiling</i>                |
| <i>novelty</i>            | <i>silver</i>               | <i>violin</i>                 |
| <i>non-gelling</i>        | <i>silk screen</i>          | <i>venetian blind</i>         |
| <i>Odorless</i>           | <i>slate</i>                | <i>Wall paper</i>             |
| <i>oilcloth</i>           | <i>solutions</i>            | <i>wall</i>                   |
| <i>opalescent</i>         | <i>spatter</i>              | <i>washing machine</i>        |

|                     |                     |                            |
|---------------------|---------------------|----------------------------|
| <i>water dip</i>    | <i>window shade</i> | <i>wood putty (lacquer</i> |
| <i>wax flat</i>     | <i>wiping</i>       | <i>base)</i>               |
| <i>waxing</i>       | <i>wire</i>         | <i>Zinc</i>                |
| <i>wicker ware</i>  | <i>wire wheel</i>   | <i>zone marking</i>        |
| <i>window blind</i> | <i>wood</i>         |                            |

## Adhesive Lacquers

Adhesives (cement) of various types were one of the early outlets for nitrocellulose lacquers. In this field, nitrocellulose of various viscosities are employed; preferably the medium viscosity type. The recently presented cellulose compounds find wide use in the manufacture of adhesives as well as the use of certain synthetic resins with nitrocellulose.

## Aircraft Lacquers

Nitrocellulose lacquers as applied to aircraft fabric are referred to as "dope," which is for purposes of tautening the fabric. Nitrocellulose dope produces waterproofness to such surfaces, thereby protecting the inner structure and surfaces of such objects. Aside from the fabric covering, other parts requiring protection are metallic and wood surfaces.

## Aircraft Fabric

After the applied fabric has been drawn taut by hand, it is further tautened by the application of dope. There are two kinds of aircraft dope: nitrate and acetate. The former is most generally used and is said to produce superior tautness of the surface. Schedule involved in nitrate dope coating is as follows: dope is received as a heavy viscous lacquer, reduced to applying consistency and in the instance of first coatings, it is applied by hand brush applications. In order to secure satisfactory applications, this dope is reduced with nitrate dope thinner and several thin and penetrating coatings are applied. This dope penetrates through the fabric and acts as a basis for further applications. Over this surface, when it is thoroughly dry, there is applied two or three color coats of pigmented nitrate dope. This pigmented dope is made on the same basis as the clear dope with the addition of select pigment pastes. Pigmented and semi-

pigmented dopes are also available and used to quite some extent. Lacquer enamels and aluminum bronze powder coatings are also widely used as finishing applications.

### **Aircraft Metal (Aluminum and Duraluminum)**

While there has been some question as to the necessity for finishing over aluminum, duraluminum, and similar alloys, it is considered good practice both from a protective and decorative standpoint. Aircraft manufacturers are, of course, anxious to dispense with finishing if convinced that no deleterious effects such as decrease in tensile strength, pitting of the alloys, and intergranular corrosion will result from exposure of such alloys to the elements.

In the protection by lacquers, synthetic enamels, etc., as in the coating of metallic surfaces exposed to the outdoor elements, it is of vital importance that the surface is acceptable to receiving applications of coating materials. To this end, the surface is first cleaned thoroughly, using mild chemical cleaners. The surface should be given a prime coat; zinc chromate or iron oxide and zinc chromate primers being considered satisfactory. Proper care should be exercised to see that the inside portion of all joints are thoroughly protected. Over the hardened film, synthetic lacquers, synthetic (air-drying) enamels or aluminum paints are applied.

### **Baking Finishes and Baking Ovens**

While nitrocellulose lacquers are, generally speaking, air-drying products, there is often a necessity of force-drying schedules. In the true sense of the word this is not considered baking (baking being associated with temperatures above 200° F). The motor car, refrigerator and similar industries present a great outlet of nitrocellulose lacquers which in most instances involve an oil type or synthetic undercoating material. Such undercoats are baked and oxidation and polymerization are hastened as the baking temperature is increased. These undercoats are advocated in view of their great degree of expansion and contraction and are rendered acceptable to the application of nitrocellulose lacquers through such baking. A slow process is used to secure best results; that is, the film is surface dried before it is subjected to baking. High heats at first will produce

pitted or unsatisfactory results while thorough penetration through concentrated heats is necessary for satisfactory results. (Industrial baking ovens are illustrated, see illustration No. 25.)

There are many finishes which require exact results that may only be secured by thorough baking. Lacquers applied over such baked surfaces tend to penetrate into the undercoating materials and gain anchorage. The thoroughness of baking the undercoats renders the surface impervious to lifting when lacquers are applied. Properly baked finishes produce a tough body or film deposit and resist



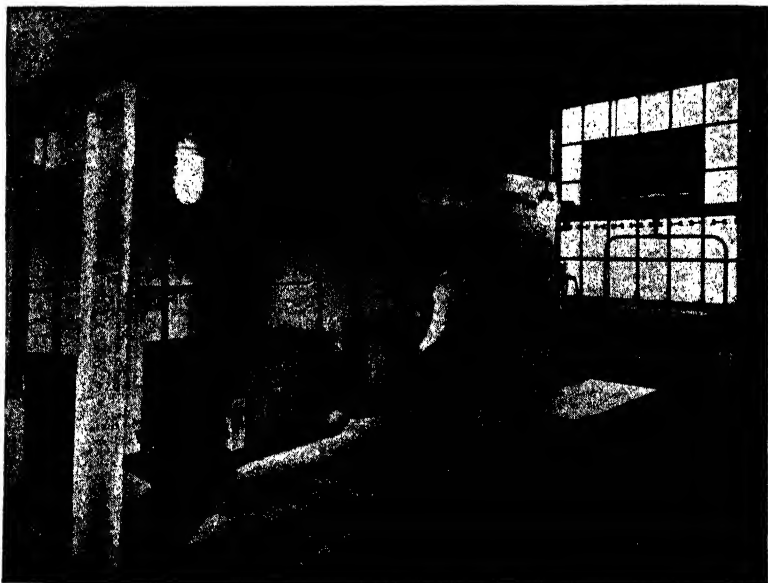
*Gehrich Oven Corp.*

FIG. 25. Conveyor oven

abrasion. The use of synthetic resinous compounds with or without nitrocellulose will produce a desirable baking finish. Today there are increasing amounts of synthetic resin employed with corresponding increases in temperature.

Baking finishes may be applied through dipping, spraying, flowing, brushing, tumbling, roller coating, and processing. Clean surfaces are important to the performance of the finishing material. Rust, oil, and grease must be thoroughly cleaned from the surface before the coating is applied. A continuous conveyor lacquer dipping and drying oven is illustrated (see illustration No. 26).

In motor car production, baking ovens are strategically located "on the line" to hasten the evaporation of volatiles in a given lacquer film, so that the finish will be ready to receive rubbing, striping, and polishing.



*Industrial Finishing*

FIG. 26. Drying oven

There are various methods of oven heating, among which are: gas, oil, electric, steam, and hot air. Gas, oil, and electric are used for higher elevations, while the latter are used mostly for force-drying of finishes. In the former such elevated temperatures as 275° F–500° F are employed, while in the latter 160° F–275° F are used. Hot air is usually admitted to an oven by control involving Foxboro temperature controller with damper arrangement. Ovens may be secured of varying types and sizes and may be fitted with shelf, drawer, truck, car, fixed rack, lift rack, overhead trolley, or conveyor arrangement. The fixed track type is illustrated (see illustration No. 27).

Heaters are constructed by means of proper type of combustion chambers. Where oil burners are used, those of the atomized type are found to give best results.

The ventilation and circulation of air within an oven is of great importance. The ventilation must carry off the vapors or fumes and supply oxygen so necessary to harden the material. Thorough circulation is necessary to distribute the fresh air and equalize the temperature to secure a uniform bake. The distribution of heat and oxygen to all parts of the oven is necessary.



FIG. 27. Drying ovens

*Industrial Finishing*

### Bleaching Lacquers

It is often considered advisable to lighten certain woods to a more uniform color and eliminate the dark sap streaks which would be magnified by the application of clear finishing lacquers.

The former practice was to bleach the wood, using strong bleaching agents. In this practice the chemicals used must be thoroughly cleaned from the surface. This necessitates a water wash and consequently a sufficient time for the wood to free itself of moisture.

Bleaching lacquers, which have the combined function of lightening the wood and of acting as a sealer coat for further applications of clear wood lacquers, are used and have met with great favor in the industry. Such a material is applied by spray, brush, or with sponge directly onto the wood. When thoroughly dry, paste wood fillers may be applied, followed by clear or flat wood lacquer. These

lacquers are shipped in glass containers and at applying consistency.

Satisfactory imitation inlay or two-tone work on panelling or drawer fronts may be produced. Extra light work may be secured through double applications of the bleaching lacquer.

### **Non-Gelling Bronzing Lacquers**

In the earlier days of lacquer manufacture such phenomenon as "gelling" or "livering" of lacquers was of common occurrence. This action was accompanied by a decided greenish tinge to solutions which involved bronze or copper powder. During this period of lacquer manufacture, with limited raw materials of uncontrollable manufacture (with respect to acidity, etc.), such conditions were bound to exist.

With closer chemical control over the manufacture of lacquer raw materials and selective lacquer formulation with respect to acidity of nitrocellulose, solvents, and resins, this condition was lessened to a very marked degree.

It is common practice to ship clear bronzing lacquers and add the bronze powder to the lacquer prior to its use, and it has been found most satisfactory to ship such lacquers at a consistency which will require reduction before use. The bronze powder is added to the thinner which in turn is mixed with the lacquer. Lacquers showing practically no tendency to gel (after 6 days) are constructed of medium viscosity nitrocellulose, ester gum (acid number of 6 or less), or dammar gum and a volatile solvent made up of 60% solvent and 40% non-solvent. This period (6 days) is cited as it appears to be the greatest length of time to which a mixture is subjected before further use. Tests on this material have been conducted after a period of four months' standing and was found to be satisfactory.

In proportions up to .75%, benzoic and oxalic acids as well as Stabilisol "A" are effective as gel preventers. Stabilizers or inhibitors are used to a large extent. Ethylene dichloride is found to be a gel-preventer and is better suited if the lacquer is stored in tin containers (11), (12).

### **Broom Handle Lacquers**

Such lacquer products which are applied by squeegee application are of a very viscous nature. Being truly a nitrocellulose product they

constitute: nitrocellulose, solvents, resins, plasticisers, and/or pigment matter. High viscosity nitrocellulose is used and most frequently a 15 or 20 pound cut of ester gum is used to aid in securing high solids and lustre. Film scrap often enters into structural formula because of cheapness and good film building properties.

Lacquer paste colors ground on the stone or roller mills may be used or dry pigments may be ground into some of the thinner liquids (low viscosity) of the formula through the medium of the ball or pebble mills and added directly as a mill base to the remainder of the formula. In such an event, bold gum or resin may be added direct to the mill as a portion of the grinding vehicle (it is assumed that wax free gum resins will be employed) .

Such lacquers, because of their viscous nature, are usually shipped in 5 gallon kits. If shipped in drums, agitator I.C.C. No. 5 drums are used. Thinners are very seldom used, except for first coat applications on bare woods, and are sometimes added in view of evaporation through use.

Metallic bronze powders are added to clear lacquers to secure a metallic effect. These additions require care and are customarily added prior to use by the handle manufacturer.

Broom handle lacquers should be carefully constructed from virgin nitrocellulose, raw material acidity carefully checked and "rich" solvents used. Such careful formulation retards the "livering" action which may accompany bronze powders in lacquers.

### **Cable Lacquers**

Nitrocellulose coatings applied to wire cables provide good electric insulation, withstand severe temperature changes and remain flexible for an indefinite period of time.

There are three types: low tension, intermediate, and high tension. The lacquer is applied by squeegee and the cable is drawn into towers where the lacquer is dried. Ethyl cellulose is recommended for this coating outlet.

### **Casket Lacquers**

Caskets or burial cases which are coated with a lacquer finish are constructed of wood, sham (an exponent of the cloth covered wood



caskets), and metal. Each surface requires different types of finishing materials and each surface indicating procedure to a finish.

In the finishing of wooden casket surfaces, the procedure involves the identical schedule as the furniture finishing industry, i.e., stain and/or wood filler and clear and/or flat wood lacquers. Enamel finishes are also used and the wood surfaces may be filled by using either a lacquer surfacer or an oil surfacer, followed by lacquer enamels. Lacquer finishes which involve metallic bronze added directly to the lacquer have met with great favor. Clear lacquer is applied overall.

In the instance of zinc caskets, this metal is used because of its non-rusting qualities. The zinc itself in some instances is not protected with lacquers. In the event the zinc is coated, a smooth and clean surface is first attained using lacquer cleaner and thorough sanding. Such surfaces are customarily finished in silver bronze. Here the aluminum powder is added to the clear lacquer and high lighted with a black lacquer.

Body steel is often used in casket manufacture. Here the procedure involved is the application of a lacquer surfacer at all welded sections. A coverall coat of surfacer, which is wet sanded, then followed by a coat of metallic bronze lacquer slightly scuffed, and followed by a double-head application of clear lacquer which is then rubbed and polished to a finish, is the customary procedure.

Crystal and wrinkle finishes appear on some of the better quality metal caskets. Certain appear in panel effect with corresponding metallic bronze lacquer effects.

### **Ceramics**

The use of lacquer in the ceramic industry is limited to coatings as applied by brushing, spraying, and dipping. Lacquer coated ceramic products are readily saleable, being attractively decorated and have the added feature of being waterproof.

After the various objects are "fired" in baking furnaces and after thoroughly cooled, a wet coat of lacquer surfacer is applied by spray-gun application. This may be followed by still another surfacer application in view of the porosity of the surface. When the surfacing material is thoroughly dry, various colored lacquers are applied

directly over the surfacer coating. The colors, of a concentrated nature, produce solid coverage in one application, which results in a natural lacquer enamel lustre. The lustre can be increased through the addition of clear finishing lacquers. Synthetic enamels, as a one coat application, are favored from a cost standpoint.

Plaster of Paris molds, exemplified by the various types of statuary, are in like manner finished in lacquer enamel. In the use of lacquers on such surfaces, consideration should be given the porosity of the surface. The resultant finished product should be free of " pinholing " which results from the porous nature of the surface. Surfacing materials, especially those applied to the finer quality of statuary, are sanded very smoothly. The resulting finish must maintain a high lustre and a lacquer of relatively high resin content is recommended.

### Crackle Lacquers

Crackle lacquers are basic nitrocellulose products which are compounded mostly of volatile liquids and pigment. The pigment is present in excessive amounts, while minimum amounts of nitrocellulose and resin (as binders) are used. Unlike the usual type of nitrocellulose enamels, dry pigments are used to produce this novel finishing effect, instead of the paste type. In view of small proportions of nitrocellulose present, the base may be " ground " in a ball or pebble mill with the pigment. Crackle lacquers are a phenomena of coefficient of film expansion.

The crackle lacquers may be secured in both clear and colors. Crackle lacquers find an outlet in both the wood and metal finishing industries.

Best results are secured through spray-gun application at about 30 to 40 pounds spraying pressure. Crackle lacquers are usually shipped at a consistency that requires reduction for spray application. Reduction amounts depend upon the operator and the size of crackle desired. Thinner should be of the " fast " evaporating type.

An application of clear or colored lacquer must first be applied to the object, thoroughly dried, and the crackle lacquer applied. In view of the presence of low boiling solvents, the crackle lacquer will dry very rapidly. As evaporation takes place, the film of lacquer will

break apart and form crevices or island-like formations in the finish, showing the undercoat contrast and thus producing a two color effect. A thin application will produce a smaller effect on the work, whereas heavier applications will produce the large intricate designs. Excessive reduction with lacquer thinner will likewise produce the small effect, while lesser reduction with thinner but an increase in air pressure will produce the larger design. After the work has been coated, the crackle action will be hastened by passing a blast of air from the gun over the fast evaporating coated surface. In view of the minimum binder present, the final crackle finish is not considered resistant to abrasion, etc., therefore an application of either clear or flat finishing lacquer should be applied over the entire surface.

### Crystallizing Lacquers

This is a basic nitrocellulose product that is classed as a novelty finish. Crystallization is due to materials that are employed which, while initially soluble in the lacquer structure, become partially insoluble or crystallize slowly from the film after application. The film dries through evaporation and thereby deposits a crystalline formation on the surface of the dried film, which is similar to the frost formation on a window pane.

A wide range of formations or effects are available which produce a range of sharp geometric lines and long curvatures simulating pheasant's feathers. The crossing geometric lines producing "block-outs" which, when the volatile solvents leave the film, dry out to an opalescent effect.

Crystallizing lacquers are applied by spray application and are best adapted to metal and non-porous surfaces. These lacquers require no baking to produce this effect, but are sometimes placed in a force dry oven or chamber to assure the absence of draughts which would retard the desired effect. These lacquers should be applied using low air pressure (20 pounds on the gun line) and require a longer period of air dry than the ordinary lacquers. The clear type produces the most exacting results, while the pigmented types are retarded in their wide spreading and variegated formations due to the pigment additions. The modernistic designs resulting from this lacquer are controlled both by the lacquer manufacturer in formulation and the

operator who applied the finish. A full wet-coat of lacquer is applied, free of blasts of air over the wet surface while in the course of application and drying. As in the instance where any finishing material requires a certain amount to finish a given surface, so does it require a certain amount of crystallizing lacquer to produce this effect.

Crystallizing lacquers are primarily intended as a one coat finish and are intended for interior rather than exterior use. There are several methods of finishing over the various surfaces and it appears each operator has his own method of producing a given effect. For wooden surfaces which involve coloring matter, the best results are secured by applying ordinary colored lacquers or paint enamels direct to the prepared surface. Over this thoroughly dried surface, a crystallizing lacquer sealer is applied and permitted to air-dry overnight. The crystal lacquer is then sprayed over the sealer, producing a novelty finish of great richness.

On smooth metal where the clear finish is insufficient and may be involved, it is advisable to apply a baking type of enamel. Over this a clear crystal lacquer is applied, producing the color contrast with crystal finish on the top surface. Often a clear crystal is applied direct to the bare metal and when thoroughly dry, colors ground in Japan and reduced with pure gum spirits of turpentine, are brushed or wiped over the entire surface. This is then wiped free with a soft rag. The polychrome effect thus produced will "stop" the line formation of crystalline effect, and a protective coat of lacquer may be applied over the crystallized lacquer surface.

### Dipping Lacquers

These are usually heavy bodied lacquers (high viscosity). Lacquers of this type find a great outlet as coatings for brush handles, pencils and wood turnings. Dipping lacquers are not composed of the high solid content as in the instance of a wood finishing lacquer.

Dipping lacquers are commonly applied either by hand, machine, or squeegee dipping methods. In the toy industry, such lacquers find great outlets. Dipping machines are constructed to dip by immersion and slow withdrawal and can coat upward of 50,000 objects per day.

The reduction of dipping lacquers is in accord with the object being

coated, e.g., if projections are present, thinner is added to a free flowing lacquer drip.

Many metal objects are coated with synthetic enamels. Such coatings require baking after dipping, to produce glossy, hard durable finishes.

### **Drawer Coater Lacquers**

There is no definite schedule of finishing or type of finishing material that is applicable to the inside coatings for drawers. Among the various schedules is found:

- (1) stain to a finish;
- (2) one coat shellac, then waxed. The wax may or may not contain coloring matter;
- (3) one coat shellac, then followed by a coat of flat lacquer;
- (4) one coat clear lacquer, then waxed;
- (5) one coat wax, thinner with gasoline to which has been added color in oil;
- (6) one coat flat lacquer, to which has been added color matter to coincide with the table finish.

Some finishing schedules require no sanding or filling prior to applications, and may be applied by brush, spray, or with a saturated rag.

### **Emulsion Lacquers**

Lacquer emulsion coatings for industrial use have recently made their appearance. The general process of nitrocellulose emulsion lacquers has been perfected by the Hercules Powder Company who hold the basic patents. Emulsion lacquers are available in clear and colored finishes and permit the application of a higher solid content than heretofore has been possible. They also present lower application costs than is possible with present day lacquers.

These lacquers are sprayable despite the increase in non-volatile content. Of decided advantage is the reduction of the fire hazard. When they are applied to a porous surface, there is less tendency toward penetration which gives a much better surface coat with less material,

Any type of nitrocellulose may be used in the preparation of the emulsion. The type used, however, is dependent on the solid content desired in the finished product. In formulation, plasticiser and resins of the general lacquer type may be used. Solvents, however, should be very selective — this choice is very important. In general, they should be water immiscible. Humidity of the air surrounding the drying of the lacquer emulsion is also very important.

Lacquer emulsions are made in two parts — the lacquer phase which is the base lacquer and the water phase which contains the emulsifying agent. These two phases are joined in a colloid mill or a homogenizer.

Lacquer emulsions are suitable for finishing automobiles, furniture, etc., and seem particularly adapted to paper coating, fibre, cloth, adhesives, and in general any porous surface.

The application may involve brushing, spraying, dipping, or roller coating.

### Hat Lacquers

Until recent years, soft braid and fibre hats were coated with animal glue sizings. The uncontrollable workings of this sizing, particularly during the warm weather, dictated a change in finishing materials. Objection to the odor of the glue during the sizing also had bearing on the change.

Sizing materials are necessary to produce requisite stiffening to hold the shape of the hat. The hat is first immersed in a water dye of the proper shade and permitted to dry thoroughly. Under some conditions this is given an overnight dry and after thorough drying the hat is hand dipped into a rather shallow dipping tank which contains the clear lacquer size. The lacquer is reduced to applying consistency by the introduction of thinner recommended by the manufacturer of the lacquer. The reduction will vary from equal volumes to two parts of thinner and one part of lacquer. When reduction is completed, the tank should be covered; air bubbles are permitted to rise to the surface before dipping proceeds.

The hats are dipped, withdrawn, and allowed to drain. The excess drainings are confined to a receptacle and returned to the tank. After a few minutes of draining, they are placed on racks and permitted to

dry for two hours, whence they are placed on shaper blocks. Here they are pressed and formed into various shapes under steam pressure and are passed on for trimming. Some types necessitate two dips.

The water whiteness of lacquer is an advantage as is the speed of drying found in lacquers. The stiffening of the fibre is greater than glue size and waterproofness is unsurpassed. Lacquer properly designed under conditions met with in this type should be resistant to blushing which deposits a "white" surface and may result in rejection of the hat. A common fault in this trade is "bridging" or "windowing." This is described as a lustre spot where the lacquer has bridged across the mesh forming what is described as a "window."

Hat manufacturing establishments are usually small and very poorly ventilated in view of using lacquer in open dipping tanks. Hand dip application confines the operator directly over the open tank; for this reason a clear lacquer free of objectionable odor is required.

Types of hats on which lacquers are used are: straw, hair, leghorn, pedaline and visca braid.

### Heat Resisting Lacquers

Lacquers as applied to oil, gas, and electric stoves are classified as "heat resisting." They have definite color appeal and result in a saleable article. Various color schemes are employed which fit in with the kitchen color scheme. Heat resisting lacquers are also used on water heaters.

In order to secure most satisfactory results where such surfaces are more susceptible to contact with high heats, an oil type primer is baked on the surface. Baking temperatures usually involve heats of 275°F–300°F for a period of about one hour. Such temperatures necessitate an oil primer that will readily accept lacquer applications without fear of "lifting." The lacquer enamels are of a concentrated form with respect to color and produce solid coverage in one application. These lacquers are intended for spray application and directions for reduction should be closely followed. Usually such products require about 25% reduction, although products may be secured requiring equal volumes of reduction with lacquer thinner. From the standpoint of the resistance of such lacquers to heat, and the realiza-

tion of possible disintegration of a straight nitrocellulose lacquer film in contact with high temperature, the structural formula of such lacquers would necessarily involve synthetic resin of the oil modified type.

Where such lacquers are not in contact with heat, oil baked primer coat is eliminated and lacquer is applied directly to the metal surface.

Such lacquers are usually of high lustre and frequently a finishing coat comprising 40% color and 60% clear is applied. This finishing application is reduced to a greater extent than the color coats, thereby resulting in a surface of good leveling and high lustre characteristics.

For most practical purposes, synthetic enamel finishes are recommended.

### **Imitation Marble Lacquer Finishes**

With respect to hand brush applications, nitrocellulose lacquers are too fast drying to be considered applicable to the art of imitating marble finishes. As a near approach, veiling lacquers, applied by spray gun and involving low air pressure is recommended. The use of the "string whip" process, which is a hand application, produces satisfactory results. Through this method, ground coats must first be applied (spray) and the colors in which the cord is dipped must be of a contrasting shade. Recent applications which involve lacquer paste, silk screen stencil and newspaper have produced many satisfactory finishes which are applicable to glass table tops, etc., and closely approach a marble finish.

### **Imitation Mother-of-Pearl Finish**

Mother-of-pearl finish is applied to artificial pearls, jewelry, buttons, lamps, art objects, etc. This effect is created in a quick drying lacquer to which has been added an essence produced from fish-scales. A very brilliant lustre and a silver sheen result from this finish.

Specially constructed lacquers, rich in solvent, produce the best results. A minimum amount of the essence is required which may be applied directly or added to a clear lacquer. A few drops of dye solution are customarily added in order to produce a pink tinge.

Recently there has been introduced an essence known as "H"

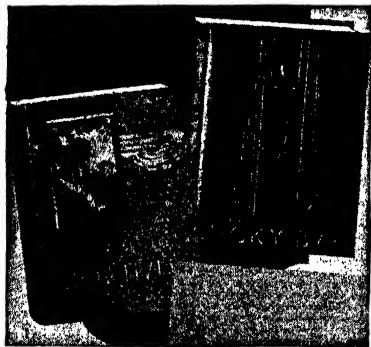


scale. This essence, as direct applications or in admixture with lacquers of clear nature, is applied over colored motor car finishes to produce a most desirable and rich effect. Aluminum bronze powder added to colored motor car finishes is sometimes used to produce a comparable effect. Additions to metallic base lacquers which are applied over wrinkle finishes produce very pleasing effects. Another very attractive finish may be secured by using "H" scale lacquers as a base and by spattering red, blue, black, and yellow lacquers on the surface.

### Leather Lacquers

The use of nitrocellulose lacquers on leather surfaces is one of the oldest uses to which this coating medium has been applied. Leather "dopes," as these lacquers are known, are used in the split, patent, and artificial leather industries and also in leather belting trade as a cement.

Lacquers are used in the bookbinding industry. Such schedules for finishing would involve embossing lacquers, base colors (paint base), which are reduced with lacquer thinner, wiping thinner (lacquer base), and waxing or buffing to a finished product. (See illustration No. 28.)



*Industrial Finishing*

FIG. 28. Book covers

In the use of belting cement, the leather is split and roughened with a wire brush and the cement, reduced to applying consistency, is applied with a hand brush. The sides are joined and forced together

with wooden clamps and slowly passed into a heated chamber or they may be air-dried. The roughened edges become thoroughly knitted and result in remarkable adhesion.

In the use of lacquer as applied to gladstone bags, etc., the cowhide sidings are brush coated with colors in oil which is reduced with a lacquer thinner. They are then placed in a heated mold where the graining effect is imprinted. After thoroughly dry, the side is

“ backed ” with cardboard and shaped into frames. Lacquer coatings are applied overall, rendering a waterproof surface.

### Linoleum Lacquers

Attempts to use lacquer enamel in the actual production of linoleum have met with little success. While pigmented lacquers may be constructed which will resist abrasion and alkali, are workable in application, do not attack paint undercoats, dry with a good gloss, have good covering and have little or no after odor, they do not satisfactorily withstand the linoleum bend test. The abrasion resistance of such products is satisfactory; this, however, is considered resistance as an applied film to wearing action and is not to be confused with abrasion as applied to non-porous materials. When linoleum has been completed in manufacture, it is subject to rolling and it is this bend and pressure print test that condemns the use of lacquers. The use of synthetic resins with minimum amounts of nitrocellulose may present a combination that should meet with success.

Lacquers, when applied on linoleum surfaces, entail roller coating device as the method of application. One of the more common faults in past attempts at using lacquers was pinholes in the film. At that time, these were attributed to too heavy applications of lacquer over the printed felt base (asphaltum, etc.) . Over this base, a varnish first coater was applied and the use of lacquer over a varnish caused a lifting action. Suction and sticking to the rollers were other common faults at that time. Heat and plasticiser content was attributed as the probable cause. Softening and smearing of the design may also be corrected by the proper selection of volatile matter. As mentioned previously, it is believed that a lacquer product employing synthetic resins will overcome these undesirable features.

When kitchen laid linoleum becomes “ lifeless ” through constant use (wear and cleaning) , it is revived by the use of a clear water-white linoleum brushing lacquer. This product, of nitrocellulose base, is subject to brush application and for this reason, it is constructed so as to produce proper brushability and may therefore be brushed at great length. In applying such lacquers, always begin to brush away from and toward the point at which the previous brush full of lacquer terminated. This will permit an even coating free of undue rough-

ness. The product is of applying consistency and should always be applied with a full wetted brush of lacquer. A clean floor, free of dirt, grease, and wax is essential to satisfactory results.

### **Clear Metal Lacquer Finishes**

The use of clear lacquer as applied on metal was one of the early uses to which nitrocellulose lacquers were applied. The quick drying features, its waterproofness and such characteristics have made it valuable to the metal industry. Lacquer preserves a metal surface so that rust, corrosion, and tarnishing do not occur. Lacquers as applied to such surfaces are harder and more resistant to abrasion than the film of any other similar finish. Among the various types are: brass, bronze, silver, water dip, copper, chromium, and such finishes as used on the various metals.

The electroplating industry is a large user of clear metal lacquers. In the application of lacquers in this industry, care should be exercised to place the spray operation sufficiently far away from the plating tanks, as the close proximity here is responsible for many faults in the finish.

Lacquers for use in clear metal finishes require carefully balanced proportions of the various ingredients. A thin film is required and such deposits must be arrived at through minimum reduction with lacquer thinner. "Dope" nitrocellulose (15 second to 60 second type) is used. The films produced with this raw material are very tough and such lacquers are usually of high lustre.

Synthetic resins and certain of the recently introduced cellulose compounds find possible outlets in the production of resisting and durable clear metal finishes.

### **Colored Lacquer Finishes**

The important requisite to consider in this type of finish is the preparation of the surface. Before the application of lacquers is considered, the surface should be rendered free of grease, oil, or rust. The grease or oil is best freed from the metal through the use of a cleaning solvent, while the rust might be treated with a patented cleaner or sandblasted. The cleaning of metal is described under **FAULTS AND CORRECTIONS**.

The type of primer, surfacer, or primer-surfacer combination has an influence on the final result. An oil base primer or surfacer is advocated as this will permit a great degree of expansion and contraction. Knifing glaze is essentially a part of such finishing schedules in view of the great pitting and leafiness of the metal. It is common practice to apply a lacquer primer-surfacer over the oil base primer or surfacer. This lacquer primer-surfacer is termed an "intermediate coater" and is intended to smooth over the deep metal imperfections or markings left by the sandpaper operation. In certain schedules, sanding is not resorted to until after the lacquer surfacer has been applied. This then produces an even surface, ready to accept lacquer applications. Where light colors are used to a finish, the primer-surfacer may be tinted with some of the finishing lacquer.

Lacquer enamels are formulated along the lines of producing great flexibility and are resistant to grease, oil, gasoline, alkali, and abrasion.

Of interest to the metal coating industry is the recent cellulose compounds presented by the Hercules Powder Company. When made into coatings, these cellulose derivatives will resist ultimate deterioration to a greater extent than nitrocellulose finishes.

### **Odorless Lacquers**

The use of lacquers for office buildings, refrigerator interiors, etc., dictate that the lacquer must have a mild odor. A nitrocellulose lacquer entirely free of odor cannot be manufactured. Lacquers which produce a pleasant odor and are applicable to such use must be constructed of chemically pure solvents which will leave no harsh residual odor in the lacquer film.

The ethylene glycol series of solvents are considered of very mild and ethereal-like odor which meet with the requirements and find an outlet in the development of such products. Lacquers, especially for use in refrigerator interiors, should be carefully constructed in view of edible food product storage and possible contamination.

### **Paper, Fibre and Fabric Lacquers**

Waterproofing applications on porous surfaces, i.e., paper, novelties, maps, shot-gun shells, and fibre bathroom tile, have always been

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a problem for the lacquer chemist. Aside from adhesion to a surface of greasy nature, there is to consider the stiffening action and resultant curling of the paper. Regularly formulated standard lacquers have been used with little success. Dammar resin has been used and both camphor and paraffin oils used as plasticisers. The latter, because of its low melting point was discarded. Castor oil produces too tacky a surface. Where there is a definite tautness desired, little trouble is experienced using a regular clear metal-type lacquer.

The use of lacquers as a protection to paper objects such as labels, signs, boxes, etc., has met with great approval. Such advantages as moisture-proofness, grease resistance, gasoline, and oil resistance are of definite concern.

Lacquer as applied is a flexible material of medium lustre. It is particularly adopted to roller coating in which a Chambers Coating Machine is used. Drying may be adjusted so that sheets may be stacked when coming from the drier. Temperature of the drier is maintained at 120°F–130°F. The ventilation in this compartment is very important since circulation of air is essential to maximum drying characteristics. Traveling in the conveyor takes about 45 seconds to a minute, and the sheets are run for approximately the same distance outside the oven to allow the sheets to cool. They are then stacked one upon the other.

It is necessary to keep a careful control of the viscosity of the lacquer during the coating operation. Thinners will evaporate as the material is used and must be replaced in order to maintain a workable consistency.

For cardboard, crepe, and similar type paper coatings, lacquer emulsions find a great outlet today. Lacquered paper resists water, is washable, possesses a clear film, intensifies and brightens colors, adds lustre, withstands chafing and scuffing in shipping and handling, resists fats, oils, acids, alkalies, and stains, and does not discolor white or light surfaces or darken with age.

Pressed fibre as used in the production of bathroom tile presents somewhat of a finishing problem. A bond coat of oil nature is advocated, the surface having been previously roughened to insure thorough penetration and adhesion. Over this bond coat a pigmented oil surface is applied. These applications are each baked at elevated

temperatures and then sanded, using a 320 grade of paper followed by a 400 grade. Lacquer primer-surfacer may then be applied as an intermediate coating but is customarily omitted if the surface is smooth. If primer-surfacer is applied, it is, of course, properly sanded. Two double head coats of synthetic lacquer enamel are applied. This finish is "scuffed" with 400 paper and a final operation of a mixture of 40% color and 60% clear is applied.

### **Lacquer Putty (Wood Putty)**

This is a nitrocellulose product of a heavy, dough-like consistency and is used to fill the deep crevices, nail holes, etc., in wood surfaces. It is applied with a putty knife and is well packed with the edge of the knife and leveled smoothly with the face of the knife.

Sufficient time should be allotted for the solvents to evaporate from the putty and shrinkage (if present) to take place. If shrinkage is too great, an additional application should be applied. When the surface is filled, rough edges should be sanded smooth and a thin film of lacquer applied. The finish may then be coated in the regular manner.

### **Lacquer Putty (Metal Putty)**

In the application of lacquer putty on metal surfaces, the procedure is a little different. The entire surface is first coated with the colored lacquer or undercoating material and permitted to dry. The putty is applied, feathered with fine paper (400 grade) and finishing materials are applied.

### **Roller Coating Lacquer**

Lacquer is usually applied by this process on flat surfaces and is applied by a machine which is composed of a series of rubber composition and metal rollers. The lower roller revolves in a material container which deposits the lacquer on other rollers and eventually on the surface to be coated. The type of lacquer is heavy bodied and similar to a dipping lacquer (in viscosity) but of higher solids.

Applications by the roller coating method, wherein the newer synthetic enamels or synthetic resin-lacquers are employed, has met with great favor. This method of application is particularly adopted to finishing signs, bathroom tile, and similar flat surfaces.

### Railway Finishes

Lacquer provides a hard and durable finish to railway coaches which will resist abuse to a greater extent than varnishes, etc. A number of railway companies have adopted the use of lacquers on pullman coaches for several reasons, chief among which are:

- (1) A shorter schedule which will not tie-up the car over a long period.
- (2) Rapid dry which will permit application in the shop and less worry about the tacky appearance of other finishing materials.
- (3) Mechanical application and labor saving.
- (4) Lacquers increase in lustre and appearance through age. They resist alkalies and washing solutions and do not "deadens" and become lifeless.
- (5) Ease of patching.

The stress and strain of the long passenger coaches in passing over crossings and around curves set up a weaving action in the metal bodies. This action tends to break the film where the seams are riveted and also at the windows. Such film ruptures will permit moisture to enter and cause the film to flake off. Oil type undercoaters are advocated under the lacquer schedule. These oil undercoats will expand and contract under exerted stress placed on the metal bodies. They should be constructed to accept the application of lacquers without "pick-ups." Lacquers are waterproof and are of the flexible type.

The following finishing schedule is recommended:

Sandblast the entire surface to remove rust and dirt. This will etch or roughen the surface so that satisfactory adhesion will result. Pass air over the entire surface to insure a dust free surface.

Apply by spray gun application, a coat of red oxide oil type primer, or synthetic base primer may be used. Material is reduced to applying consistency with the proper reducer and allowed to air-dry for at least 18 to 24 hours.

Apply glazing putty with knife. Air-dry for at least 6 hours and water sand the entire surface. Wait sufficient time (at least 3 hours) for the moisture to evaporate.

Apply lacquer primer and surfacer which will fill the crevices left by the sandpaper. Sand lightly.

Apply two double head coats of dark olive green lacquer enamel which has been properly reduced. Sand between coats if necessary. This enamel should be of a flexible nature (synthetic lacquer) and for this reason, sufficient time should be allotted for the solvents to evaporate before sanding.

Apply a coat of mist-coat reducer or a clear finishing lacquer. A mixture of 40% lacquer enamel and 60% clear may replace the clear finishing lacquer.

Stripe and letter or use aluminum or gold leaf followed with lacquer or varnish protective coating.

### Refrigerator Finishing

In the selection of finishing materials to be used for decorative and protective coatings on metal electric refrigerators, consideration should be accorded its ability to withstand the stress and strain to which the surface is subjected. A well-compounded coating withstanding such elements may be considered durable. Method of application and daily production likewise has bearing on the selection of finishing materials.

In consideration of the close proximity of a motor car surface and schedule to that of a refrigerator, and realizing the expansion and contraction of metal surfaces under similar conditions in use, has indicated a partial similarity of finishing schedule. Finishing materials are an important factor in refrigerators as in motor cars, furniture, etc.

White finishing materials are used which are indicative of "cold" colors. It is the nature of white finishes to revert to a slight yellow cast on exposure, therefore, consideration should be directed to the proper ingredients employed in whatever type of material is used. Mention has been made of the comparison of motor car finishes with that of refrigerators; this statement refers to securing firm foundation coatings and great care in securing chemically clean surfaces. Refrigerator finishes must withstand kitchen greases and fruit acids, they must be capable to ease of patching and they must produce a high gloss and level film, free of "orange peel" effect.

Metal refrigerators are constructed of galvaneel or cold rolled



steel and occasionally galvanized iron is used. This latter surface is well known and needs no description here. Galvaneel is a zinc coated surface in which the zinc is deposited by a special process. This surface eliminates the greasy metal so prevalent with steel. This zinc deposited surface will withstand the action of bending, crimping and stamping. The indication of amalgamation of the zinc with the basic metal requires no preliminary chemical and/or acid treatment (as in the case with galvanized iron) to secure thorough adhesion of coatings. It is required that the cold rolled steel should be of select nature, have a smooth surface, and be free of leafiness. This type of metal surface is used quite exclusively in the refrigerator industry and the following schedule will involve the use of this metal.

The coating material described in the following schedule will involve an oil type baking primer which is finished with lacquer. It is the nature of such surfacing materials to imbed themselves in any metal imperfections which are immediately magnified. For this reason, the cold rolled metal should be received free of flaws, leafiness, etc.

The success or failure of the finish depends very largely on the thoroughness with which the steel has been cleaned. Irrespective of how well the finishing materials have been compounded, if the surface is not thoroughly cleaned, the finish will not be durable. In large production establishments, after the single piece units have been welded together and the legs secured, it is common practice to suspend the shells from an overhead trolley conveyor and pass them through a cleaning chemical hot water bath. After passing through this tank, they enter a drying oven and after passing through this operation, are carried onto the finishing line. As the cleaning solution becomes less effective, in view of the resulting deposit of retaining greases, etc., from the cases, it is advisable to revert the conveyor line through a washing machine which, through a series of spray vents, force hot water under pressure to all parts of the case. The cases pass through a heated chamber which absorbs the moisture after the final rinse. Such washing machines eliminate any open tanks and resultant dangers and may even be extended to the preliminary cleaning operation.

Direct immersion is to be eliminated if wooden upright posts are

a part of the construction. An attempt should never be made to coat a finishing material over a greasy surface, therefore thorough freeness of grease is necessary. Deoxidine is frequently used and this chemical solution destroys the rust forming chemicals as well as rendering the surface free of grease.

Sandblasting of the surface is resorted to in some establishments. In addition to cleaning the surface, this etching operation produces a "tooth" for the oil primer, resulting in very satisfactory adhesion. The cases likewise may be passed through high temperature ovens ( $650^{\circ}\text{F}$ – $750^{\circ}\text{F}$ ) which involve 20–30 minutes. This heat will free the surface of oil or grease, but usually involves a final hand cleaning with naphtha or lacquer cleaner.

Ordinarily the presence of oil or grease on the surface should have no effect on adhesion, secured through proper baking of the oil type primer, but in order to insure against spotty-drying, it is suggested that, prior to the actual spray or dip application of the oil primer, the surface be hand cleaned with solvents. Care should be exercised in finger printing the surface after cleaning.

Where production is smaller, the cases are hand cleaned using naphtha or lacquer cleaner. Rags should be used instead of steel wool, because of the danger of frictional sparks. Cleaning solutions are inflammable; all rust spots should be sanded; waterproof sandpaper or steel wool should be used.

Among coating materials, the selection of the proper type of primer is important. This is especially true of applications on cold rolled steel. Such a primer must be of a flexible nature and of moisture resisting qualities. The primer should be white and preferably of solid coverage. This then acts as a ground coat for the finishing lacquer enamel. Synthetic high-bake ( $350^{\circ}\text{F}$ ) primer is frequently used, and should possess a minimum opacity which acts as a guide coat.

The use of a synthetic primer, through which greater pigment concentration may be attained is a decided advantage. Oil primers are customarily baked at  $225^{\circ}\text{F}$  for 60 to 90 minutes and if higher temperatures are desired,  $250^{\circ}\text{F}$  for 45 to 60 minutes may be resorted to. Higher temperatures tend to discolor the white which is the result of burning and possible weakening of the finish. Primer coats

may be applied either by dipping or spraying, and reduction should be in accordance with whichever method is employed. After spraying the primer, the cabinet should be kept in a dust free atmosphere so that the possibility of dust and foreign bodies being deposited on the wet surface may be guarded against. If dirt, etc., is present on the wet surface, baked and hardened, it would necessitate sanding and thus destroy the function of an expanding and contracting film sandwiched between the metal and finishing lacquers. Oil type surfacers are relatively of greater solid content or true film foundation than a lacquer product. For this reason, if the primer is applied by spray gun application, in addition to being applied in a separate spray booth, it should be applied by a spray man who is familiar with its application. White oil type primer of solid coverage should be applied as a bond coat. Assurance of solid coverage is not always desired, but complete surface application is quite necessary. The air pressure should be higher than that used for spraying lacquers and the primer "fogged" onto the surface first, followed by complete surface coverage.

After the primer has been applied, the cabinet "shells" should pass on the conveyor or be placed in the baking oven without interruption. (See illustration No. 29.) A preliminary "top setting" of about five minutes is satisfactory but they should not be permitted to collect dust. A hard baked surface is essential and this should be predetermined if exacting results are to be expected. An underbake will produce a "lifting" action when the lacquer is applied, while an overbake will not permit the lacquer solvents to thoroughly imbed themselves in the film, with the result of an individually dried film and resultant chipping. Predetermination mentioned above should result in the exact temperature for baking.

Gas fired ovens are frequently used. The gas burners are located at the floor base and fired into a combustion chamber. Heat is forced through the chamber and with baffle-plate arrangement, a uniform temperature and distribution of heat is maintained. Ventilation is necessary to proper baking. Oven temperature is maintained with pyrometer control.

After the cabinet passes from the baking oven, any defect or imperfection will be magnified. In order to secure a glass-like sur-

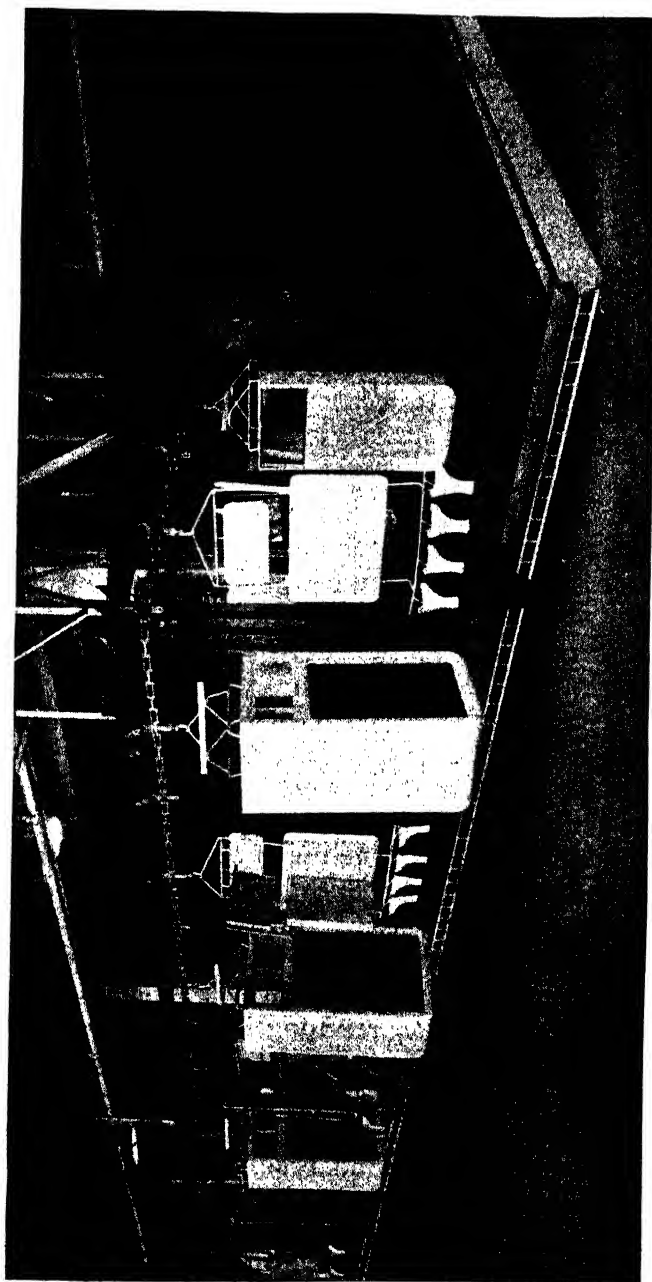


FIG. 29. Baking ovens

*R. C. Mahon & Co.*

face, characteristic of a well-surfaced job, any defects must be filled. A lacquer putty is used which is applied with a putty knife and allowed to air-dry for four hours before sanding. Great care must be exercised in sanding and feathering these rough edges. It is sometimes common practice to spot spray with the enamel over the surface to be puttied.

The finishing lacquer should be applied with spray gun, and reduction through the use of the proper reducer as recommended by the manufacturer of the lacquer should be followed. The lacquer should be of a bluish white cast. As previously mentioned, white finishing materials show a characteristic yellowing upon aging or in contact with sunlight. A blue cast will blend the yellowing tendency with the result of a pure white color. It is good practice to secure lacquer enamel in 5 gallon kits which will permit thorough agitation and incorporation of this blue which may settle beyond the reaches of the agitator paddle if shipped in drums.

Refrigerator lacquers require equal volume reduction with lacquer thinner. The last application should require greater thinning than the immediate previous coat which will produce a surface that requires minimum rubbing and polishing. The doors of the cabinet are finished separately, and when joined with it, they should match the color of the cabinet.

A refrigerator is subjected to almost constant use. Beauty and durability of finish depend on the preparation and quality of the finish and on the application. The use of an improper thinner may have bearing on film ruptures. Such ruptures may be introduced through the difference in specific gravity of the various liquids; its affinity to extend rather than to reduce the lacquer and may excite a "shortening" action to the flexible lacquer which may produce a coefficient of film expansion resulting in a top shorter than the underneath coating and producing surface cracks. Improper thinner also has bearing on the "blushing" of lacquers.

Refrigerator interiors are usually finished in vitreous enamels. Some users resort to lacquer and products are termed "odorless lacquers." A lacquer free of odor cannot be manufactured, although satisfactory products that are free of objectionable odor may be produced. Some finishers resort to "doping." Odorless lacquers

with various flavoring extracts will result in a somewhat sweet odor and if this is done, the extract is introduced into the "odorless" thinner and thence into the lacquer.

In the logical development of satisfactory coatings for refrigerator finishes, many structural formulas including solvents, plasticisers, resins, and pigment combinations were investigated. The finish itself is primarily intended for interior use; however, the stress and strain evolved through the temperature changes to which the steel is subjected, indicated such materials were comparable with motor car finishing products. This was borne out to greater extent through the possibility of cabinets remaining on the showroom floors and in windows where they were in contact with sunlight. Such lacquer finishes are, therefore, subjected to roof exposure in contact with the weather elements, blush resisting tests, water immersion tests, print resisting tests, grease resisting tests, abrasion tests, and fruit acid tests.

Most refrigerators are finished with synthetic enamels today and involve baking schedules throughout. The primer and enamel systems employed involve high temperature baking (300°F–350°F).

### Lacquer Cleaners and Removers

As important to securing the proper type of finishing materials is the fact that surfaces which are to be coated must be thoroughly cleaned and rendered free of any substance that would be objectionable to securing a satisfactory finish.

"Lacquer cleaners" are used in cleaning metal surfaces, spray guns, and removing lacquer finishes. A lacquer cleaner should be constructed of such powerful solvents as to incite definite action on grease, wax, and nitrocellulose. This latter, however, is more of a softening action. Lacquer cleaners should not be used as a reducer for lacquers. Its construction is of such nature that if used as such, precipitation of the nitrocellulose would result and a permanent blush would be presented because of the relatively low boiling solvents. To identify a cleaner from a thinner or reducer, some lacquer manufacturers incorporate a dye solution. Lacquer cleaners are applied to a surface to be cleaned with rags. The rags are saturated and passed over the metal surface; these cleaners have high propor-

tions of solvents for grease. The receptacle for the saturated rags should be frequently disposed of and not permitted to remain within the confines of the finishing room overnight.

Lacquer cleaners are kept in a handy receptacle with close proximity to the spray booth. After spraying any lacquer, if colors are to be changed or if the gun is not to be used, this cleaner is passed through the gun. Spray guns should be dismantled and immersed in the cleaner at least once each week, preferably week-ends, when most spray equipment is not being used.

### **Silk Screen Stencil Lacquers**

Lacquers of heavy paste-like consistency and high in solids are applied by transfer methods which involve the use of a rubber squeegee being passed over a silk screen and transferred to a surface; the screen being previously "blocked-out" to form the pattern or design.

Such lacquers are slow-drying, producing good leveling and sharp designs. This method is quite economical since hundreds of transfers may be press-printed with a small amount of the lacquer.

Synthetic resins are introduced with the nitrocellulose base and produce more durable printings than the straight nitrocellulose type.

### **Spatter Lacquer**

Ordinary lacquer enamels are used to produce this novel effect. A solid covering "ground coat" of desired background color is first applied on a given surface. When thoroughly dry, lacquers of contrasting or harmonizing colors are sprayed by "spattering"; that is, the air pressure is reduced and the operator holds the gun about three feet from the surface. Lacquer is applied as a mist-coat. This is sometimes referred to as "salt and pepper lacquering."

### **Stipple Lacquers**

Unlike the art of stippling with a hand brush, a lacquer stippled finish is produced through spray gun application. Such novel finishes involve the use of pressure container attached to a spray gun. The nozzle is of a special construction which permits the expulsion of large splotches of lacquer being forced on the work. The material

flow valve is opened to a greater extent than the air valve. Stipple lacquers are of heavy body and are applied through the minimum additions of thinner. The operator will best determine the proper body or consistency in view of the type of stipple desired. Often this is best controlled in the manufacture of the lacquer rather than through excessive reductions. Smooth and sharp type of stipples are generally used. In the application of stipple lacquers, the ground coat is first applied and the stipple applied directly over the surface, after the ground coat is thoroughly dry. Low air pressure should be used in applying stipple lacquers.

### **Newspaper or Sponge Stipple**

Another form of stipple is to prepare a surface with a definite film of lacquer of the desired shade and then apply a full wet coat of lacquer of a contrasting shade. The lacquer last applied should be of a slow-drying type. While in this semi-wet state, a crumbled newspaper or sponge is forced onto the wet surface, blending the ground coat with that of the top coat and producing an artistic design.

### **Synthetic Enamel Finishes**

In the formulation of industrial synthetic enamel finishes, a knowledge of the use to which the product is to serve (whether interior or exterior); temperatures to be used in "curing" the finish; gloss desired, and resistance to certain elements must be known.

In developing a synthetic enamel finish, the chemist should select the basic type of resin he must use and the modifying resin to be used for a specific enamel. For high temperature baking, he must consider the oil-modified additions and the use of a smaller amount of drier, while for furniture finishes which may require hand rubbing operations, he should consider the rosin-modified resin additions. A knowledge of the wetting properties of these resinous compounds is essential when consideration is given the dispersion of pigments. Certain synthetic resins are notably poor "wettters" and in the creation of an enamel employing this type, it is apropos to disperse the pigment in a good "wetting" resin and then add the second resin to the heavy pigment base solution.



Certain pigments, notably the reds, maroons, and blacks, retard the drying of synthetic finishes and often require higher temperatures and/or longer "baking" times. It has often been found advantageous to add one half of the amount of metal dried in the regular formula to the grinding portion of the formula and the full amount in the mixing portion of the formula.

Synthetic enamels are customarily applied by spray gun application. A spray gun of different nozzle design than that used in lacquer application is necessary to produce a film that is free of orange-peel, etc. Air pressure must be carefully checked so that atomization of the enamel is complete. The reduction of the enamel and the type of liquids used are important. A wet film deposited on the entire surface to be spray coated is very essential. The enamel must be sprayed at a viscosity sufficiently heavy but not too heavy to produce orange peel and not too thin that sagging of the enamel may result.

On most surfaces, synthetic enamel is applied as a one coat application. The surface must be clean and free of grease, finger marks, and similar foreign materials. Smooth metal, free of surface pits, rust spots and similar imperfections, is essential to secure a smooth surface.

The enamel may be sprayed as a full wet application direct to the clean metal surface, may be applied over previously baked undercoaters, or may be applied first as a thin "mist-coat" and immediately followed by a full wet coat application. After the surface has been coated completely, it should be removed from the vicinity of the spray booth so that free dust will not become deposited on the surface and should be moved toward and finally into the baking ovens. An intermediate stage is sometimes used where the coated objects are given a very short (5 or 10 minute) air-dry before entering the oven, or if the object is sprayed while on a movable track or overhead rail, the time in transit before entering the oven should be sufficient for a "setting" and liberation of some of the volatile solvents from the coating before it is in contact with the high temperatures.

There are many types of baking ovens employed, among them: gas, electric, steam, and oil, and it is essential that a good circulation of air is present in order to obtain a thorough baked and hard film. The use of infra-red drying lamps is employed by the automotive

industry with a great measure of success. These lamps are equipped with reflectors and placed strategically throughout the drying tunnel so that the maximum effect of thorough baking will result.

After baking, the finish possesses a high lustre. This may or may not be rubbed and polished and is dependent on the article itself and its ultimate use as a finished unit.

Whereas, at the outset of the present synthetic enamel industry, the chemist dealt with phenol formaldehyde resins and later with alkyd resins and its many modifications, today the trend is definitely toward organic heat-reactive coatings which are a far improvement over these earlier resinous substances.

Of special interest, some of the properties of present day synthetic enamels are:

- (1) They provide a hard, tough, glossy, and level coating on non-porous surfaces.
- (2) They likewise provide a clear, transparent film which possesses an increase of solids to furniture and porous surfaces.
- (3) They are not affected by climatic conditions, temperature changes, water, greases, and fruit acids.
- (4) They will not deteriorate and flake, chip or crack once they are "cured" or baked at their recommended baking temperatures.

These organic heat-reactive coatings are markedly improved over the phenol and alkyd coatings. Baking temperatures were customarily from 250°F to 325°F at which point the coating became infusible and insoluble. Today baking temperatures are lowered so that temperatures of 160°F are sufficient to convert the resin.

### **Traffic Lacquers**

Quick drying coatings for traffic line markers are used on highways and on city streets. These lacquers are either applied by hand brush or with machine strippers. This latter method involves a reservoir, compressed air tank, a rotating brush which cleans the highway prior to coating and a spray nozzle arrangement. In consideration of whichever method is employed, the consistency of the lacquer is controlled in accord. A single coat, applied in somewhat of a heavy application,

is used and must cover solidly. The nature of the solvent combination must be such that "bleeding" of the street composition will not result.

### **Tumbling and Whirling Lacquers**

An efficient and economical means of coating small objects is either by tumbling or whirling.

Tumbling barrels are commercially available and where wooden toys or metal parts are involved, the objects are placed in the barrel with a minimum amount of lacquer, and the barrel is set in motion. After a short time the objects are taken out, spread (so that no two touch each other) and are air-dried. They may or may not be waxed by another tumbling process, in a separate barrel.

Whirling, which is involved by centrifugal force, is a very economical means of coating such objects as golf tees, etc. Here the tees are placed in an inner perforated container and immersed into the lacquer. The container is a part of the machine, which is similar to a tray. This tray is then raised and permitting the lacquer to drip free, is set in motion, which whirls and dries the coated objects by centrifugal force. The tees may be wax tumbled to a finish.

### **Veiling Lacquers**

This novelty type of finishing lacquer is in the same category as stipple lacquers. The finish can only be applied by spray gun application. The pattern or design is varied and the handling of the gun and the air pressure dictates the result. Lacquers may be secured of any desired shade and very intriguing and desirable effects may be secured by applying one, two, and three different colors over ground coats of lacquer.

While there is a general variance in the viscosities or bodies of different lacquers, all of which has bearing on the particular type, method of application, etc., there are also variations in the amounts of air pressure required to force the lacquer to the nozzle and through the nozzle onto the work. Veiling lacquers are of high viscosity, which would ordinarily indicate high air pressure if this lacquer were to be applied in films of relative thickness.

Veiling lacquers, as their names imply, are lacquer materials which

resemble a veil, or better still, a comet with its nebula. Veiling lacquers find an outlet strictly in the industrial field, although it is sometimes used in architectural finishing. Veiling lacquers are purely novelty finishes. They are used for decorative purposes on such objects as cloth, felt, wood, and metal. In architectural finishing, they are used on wall panels and dados in theatres, restaurants, and such public buildings.

Veiling lacquers may be applied by the use of a suction feed container or by pressure feed. Low air pressure is requisite to best results. The material and air pressure should be controlled by the operator so that the result desired will be secured in consideration of the size of the desired effect. In arriving at this result, the air pressure should be turned off and with the material pressure ranging from 5 to 10 pounds, this will permit the lacquer to "dribble" from the nozzle; with a slight turn of the air induction pressure, the desired type of pattern will result.

Particular patterns are secured by suddenly opening and closing the supply of material. This is controlled by the trigger release. The gun should be moved over the surface in all directions. Too much material supplied will retard the desired effect.

### Wall Paper Lacquers

A water white lacquer of excellent durability is used as waterproofing and protective coating applications to wall paper. Such a product finds a ready market in hotels and public buildings as well as in private homes.

Wall paper lacquer is supplied at spraying consistency and may also be applied by brush applications.

Such applications prolong the life of the wall paper and permit cleaning quite readily with a damp cloth.

### Formulation

The advent of newer film forming materials of cellulosic and resin types present a wider scope of formulation. Low and high bake alkyd finishes, modified alkyd enamels, emulsion lacquers, etc., are in this enlarged scope.

Nitrocellulose lacquers using modified alkyd resins give greater

durability and present an improvement over the previous basic materials. Such lacquers have a larger percentage of resin to that previously used, increasing the adhesion and flexibility and also permitting heat treating at elevated temperatures. In this enlarged scope may also be considered emulsion lacquers for use in coating paper and for use on porous surfaces. High viscosity-high solids lacquers which are applied by spray in specially heated spray guns also meet with great favor.

In compounding a lacquer, balanced portions of the fundamental ingredients of nitrocellulose, resin, plasticiser, solvents and/or pigments are used. Consideration is given the use of such a lacquer and the method of application.

The composition of nitrocellulose lacquer will vary continuously through the course of application, until it is thoroughly dry as a film. The non-volatile remains constant but the volatile changes during the period of drying; the low boiling solvents evaporate first. These volatiles, as they evaporate, each carrying a definite responsibility in the film, will extend the non-volatile content and for this reason, proper balance of the non-volatile portion should be constant. A study of the volatile and non-volatile properties and their variation with changes in composition should be recorded diagrammatically so that each influence should be known to the formulator. An increase of the nitrocellulose content will increase toughness but decrease the lustre. The selection of nitrocellulose may more or less be an arbitrary factor. Chief consideration is availability and chemically controlled pure products. The one half second grade is customarily used while the higher viscosity types present greater film strength, increase the viscosity of the lacquer and permit "false body" applications.

The amount of nitrocellulose employed depends on the particular type of viscosity, type, and amount of resin and particular type of lacquer being made. From 8 to 16 ounces of nitrocellulose (wet 30% with alcohol) is used per gallon of liquid. The types and range in viscosities (in a given solution) cover that range of 10-15 centipoises to 1000 seconds; likewise include both regularly and alcohol soluble types.

While it is not always good practice to blend nitrocellulose of two

varying viscosities to secure one of an intermediate viscosity, occasions sometimes arise where certain stocks are depleted and blending is resorted to. A Hercules blending chart is herewith. (See illustration No. 30.)

In the logical development of lacquer products intended to meet exacting requirements, there is usual inaccuracy when describing a

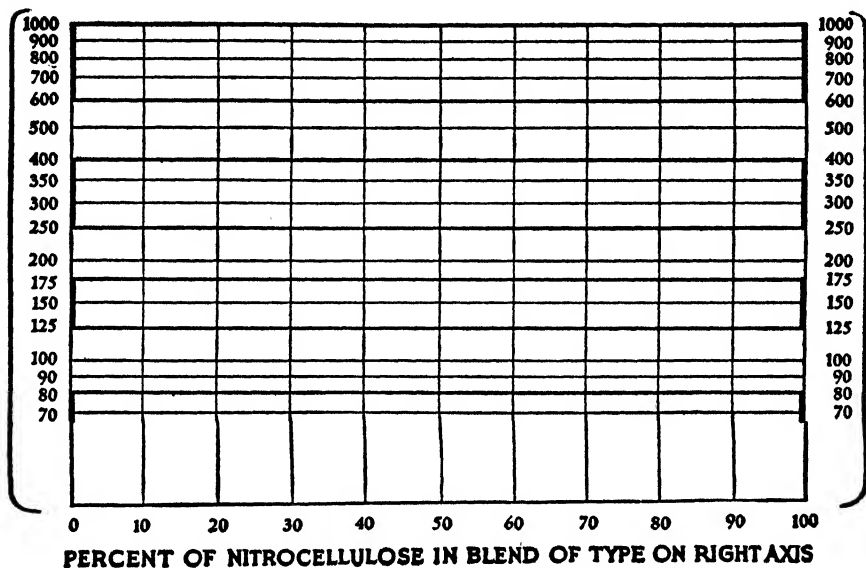


FIG. 30. Nitrocellulose blending chart

nitrocellulose solution in ounces per gallon. (Illustration No. 31 indicates such causes of inaccuracy and shows the relative difference between ounces in a gallon of solvent and ounces and a gallon of solvent; usually referred to as: IN A GALLON and TO A GALLON.)

The amount and types of resin employed will vary. Resins are added to lacquers to increase adhesion and lustre. Most lacquers have equal portions of resin to nitrocellulose, while some contain as high as 8 or 10 to 1 part of nitrocellulose. Some lacquers are entirely free of resin. The presence of the nitrocellulose improves the drying time, hardness, and water resistance of a lacquer film. Such compositions permit greater solid content at applying con-

sistency. If the resin increase proportionately is of the fossil type, the lustre would be markedly increased but a brittle film would result. The oil modifications presented in alkyd resins do not present a brittle film. Resins tend to retard the volatile evaporation and this retardation may be responsible for increase in adhesion. Practically all fossil resins detract from the durability of a lacquer and are added only to increase solids, giving lustre and adhesion to a film. Ester, dammar, and shellac are used. There are three general

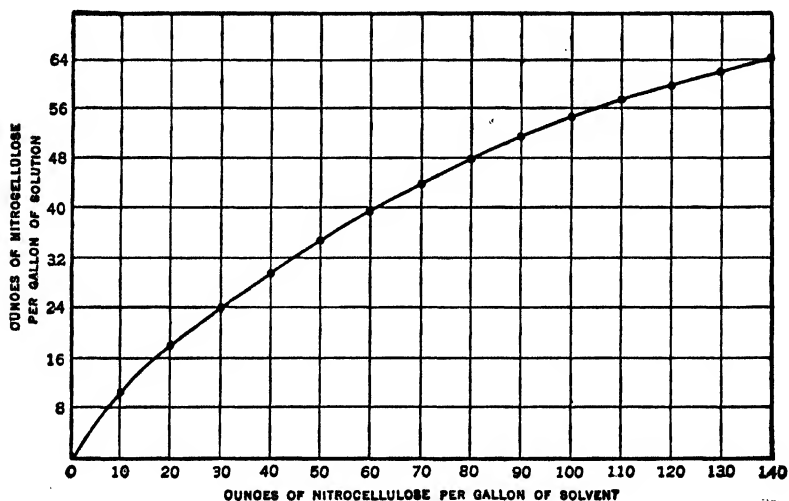


FIG. 31. Diagram of solutions

groups of resins used: natural, treated, and synthetic resins. These types are described in Part I, Chapter V.

Solvents in lacquers must be considered in view of methods of application as well as type of lacquers they are to enter. The ratio of esters, or true nitrocellulose solvents, to alcohols, hydrocarbons or gum-resins, must be balanced. The last liquid evaporating from a lacquer film must be an ester to prevent precipitation of the nitrocellulose which would cause a blush. When the reverse is the condition, a gum blush would result. Evaporation and vapor pressure curves of solvents used in compounding lacquers are important. These are mentioned under TESTS, Part III, Chapter IX.

A wide variety of materials investigated with partial conclusions are as follows:

- (1) Not much is gained by the use of petroleum hydrocarbons, considering simply cost and flow-out; though from the standpoint of odor and their tendencies not to lift, they have some advantages.
- (2) The most economical, exacting, and compatible solvent composition cannot be selected until a decision has been rendered as to the type of gum-resin selected.
- (3) A good flow-out is obtained by using high solvent power ( particularly in the latter stages of evaporation) and avoiding large amounts of low boiling solvents. Excellent flow-out combined with fairly fast drying can be obtained by using a solvent mixture as follows:

|                     |           |
|---------------------|-----------|
| Butyl acetate ..... | 30% b.w.  |
| Butyl alcohol ..... | 10        |
| Toluol .....        | 60        |
|                     | <hr/>     |
|                     | 100% b.w. |

- (4) Where ester gum is present, alcohol, cellosolve, and ethyl lactate must be avoided or used sparingly, though such solvents are essential where kauri, shellac, and other soluble gum-resins are employed.

Referring to (3) above, very good flow-out can be obtained possibly at somewhat less cost where slower drying is not objectionable. This may be accomplished by using the following composition:

|                           |           |
|---------------------------|-----------|
| Butyl acetate .....       | 30% b.w.  |
| Cellosolve .....          | 10        |
| Butyl cellosolve .....    | 5         |
| S. D. No. 1 alcohol ..... | 7         |
| Toluol .....              | 13        |
| Xylol .....               | 35        |
|                           | <hr/>     |
|                           | 100% b.w. |

Triangular coordinate charts are used to good advantage. Here the chart is intended to represent the behavior of a system containing three variables. These graphs are employed with accuracy because



the sum of the perpendiculars, from any point in an equilateral triangle to the sides, is constant.

### Non-Lifting Lacquer Solvents

There is a considerable demand for a solvent or thinner which shows the least possible tendency to lift paint or varnish films. A composition of this type follows: The petroleum distillate used should have a boiling range of approximately 80°C–125°C, and for chemically similar substances, the lower members of the homologous series usually lift less than the higher. In the following formula, the butyl acetate may be substituted for butyl cellosolve and a part of the ethyl acetate to obtain a more rapid evaporation without greatly increasing the tendency to lift:

|                            |       |      |
|----------------------------|-------|------|
| Petroleum distillate ..... | 50%   | b.w. |
| S. D. No. 1 alcohol .....  | 10    |      |
| Ethyl acetate .....        | 30    |      |
| Butyl acetate .....        | 10    |      |
|                            | <hr/> |      |
|                            | 100%  | b.w. |

### Solvents for Alcohol Soluble Gum-Resins

Shellac, kauri, pontianak and other alcohol soluble gum-resins usually require alcohols (particularly butanol) in rather large amounts to obtain flow-outs and gloss. Where the amount of alcohol in the formula is insufficient, actual precipitation of these gum-resins may occur. The following formulae are typical and the first shows where the amount of alcohol is represented as the smallest amount that can be used with dewaxed shellac without producing a gum-resin blush upon drying:

|                           |       |           |
|---------------------------|-------|-----------|
| Ethyl acetate .....       | 12%   | 25% b.w.  |
| Butyl acetate .....       | 6     | 6         |
| Benzol .....              | 40    |           |
| Toluol .....              |       | 49        |
| S. D. No. 1 alcohol ..... |       | 20        |
| Butanol .....             | 42    |           |
|                           | <hr/> |           |
|                           | 100%  | 100% b.w. |

### Plasticisers

Plasticisers usually enter into a lacquer in controlled amounts; as over additions produce non-drying lacquer films. Plasticisers in

lacquer also have bearing on amounts and types of resin added. The greater the resin content (synthetic resins are an exception), the greater the plasticiser addition. The best types to use are esters which serve as blush resisters. Heavily pigmented lacquers must be heavily plasticised. The types entering into lacquer formulation are: high boiling esters and the drying and non-drying oils.

## Pigments

The pigment content of lacquers will vary and too great an addition of pigment will produce a chalky or a non-drying condition and poor adhesion. The finesse of pigment grind is important as this has a direct bearing on many factors which will influence the lacquer film. The greatest pigment concentration is found in white pigmented lacquers. Organo-philic pigments show a greater tendency toward dispersion and the wetting of pigments is a study in itself. Dispersing liquids are advocated.

## Flow of Lacquers

If low boiling solvents are used, the rapid evaporation will not permit thorough and even drying of the lacquer film to adjust itself to changes and the result is a taut shrinking film which easily chips and is inclined to wrinkle. Use high boiling solvents to impart "spreading," which permits thin applications in smooth and uniform films.

With the consistent study being devoted to newer raw materials, lacquers are today being formulated to withstand greater abuses than that conceived a few years ago. Abrasion, hardness, scratch resistance and non-yellowing are only a few tests to which a normal lacquer is subjected.

## FORMULAS

### ADHESIVE FOR POROUS SUBSTANCES

|                               |                  |
|-------------------------------|------------------|
| H.B. Substitute shellac ..... | 60.00% b.w.      |
| Asbestine pulp .....          | 40.00            |
|                               | <u>100% b.w.</u> |

### AUTOMOBILE LACQUER BASE

|                                           |                  |
|-------------------------------------------|------------------|
| $\frac{1}{2}$ second Nitrocellulose (wet) | 19.00% b.w.      |
| Acetates .....                            | 45.50            |
| Hydrocarbons .....                        | 17.00            |
| Alcohols .....                            | 7.00             |
| Resin solutions .....                     | 8.00             |
| Plasticiser .....                         | 3.50             |
|                                           | <u>100% b.w.</u> |

*Use paste colors, 1  $\frac{1}{2}$  pounds per gallon*

**CLEAR CLOTH ADHESIVE**

|                              |             |
|------------------------------|-------------|
| Nitrocellulose base (B) .... | 86.73% b.w. |
| Plasticiser .....            | 9.95        |
| Acetates .....               | 3.32        |

100% b.w.

Total solids 25.08%

**GLOSSY BLACK BAKING ENAMEL**

|                               |            |
|-------------------------------|------------|
| High volatile carbon black .. | 4.00% b.w. |
| Beckosol No. 1 .....          | 47.00      |

*grind*

|                      |      |
|----------------------|------|
| Solvesso No. 3 ..... | 3.00 |
|----------------------|------|

|                      |       |
|----------------------|-------|
| Beckosol No. 1 ..... | 31.00 |
|----------------------|-------|

|                      |      |
|----------------------|------|
| Solvesso No. 3 ..... | 6.00 |
|----------------------|------|

|             |      |
|-------------|------|
| Xylol ..... | 9.00 |
|-------------|------|

100% b.w.

Total solids — 43%

Bake for 1 hour @ 250°F

Add driers as necessary

*Applied by spray gun***WHITE BAKING ENAMEL**

|                        |             |
|------------------------|-------------|
| Titanium dioxide ..... | 29.00% b.w. |
| Zinc oxide .....       | 1.00        |

*grind*

|                              |       |
|------------------------------|-------|
| G.E. No. 2462 resin solution | 25.50 |
|------------------------------|-------|

|             |      |
|-------------|------|
| Xylol ..... | 2.50 |
|-------------|------|

|                              |       |
|------------------------------|-------|
| G.E. No. 2462 resin solution | 37.50 |
|------------------------------|-------|

|             |      |
|-------------|------|
| Xylol ..... | 7.50 |
|-------------|------|

100% b.w.

Bake for 1 hour @ 275°–300°F

*Applied by spray gun***WHITE BAKING ENAMEL**

|                        |             |
|------------------------|-------------|
| Titanium dioxide ..... | 15.00% b.w. |
|------------------------|-------------|

|                  |      |
|------------------|------|
| Zinc oxide ..... | 4.00 |
|------------------|------|

|                              |      |
|------------------------------|------|
| F-224 Uformite solution .... | 9.00 |
|------------------------------|------|

*grind*

|                          |      |
|--------------------------|------|
| 50% alkyd solution ..... | 9.50 |
|--------------------------|------|

|               |      |
|---------------|------|
| Butanol ..... | 3.00 |
|---------------|------|

|             |      |
|-------------|------|
| Xylol ..... | 3.00 |
|-------------|------|

|                         |       |
|-------------------------|-------|
| Uformite solution ..... | 19.00 |
|-------------------------|-------|

|                      |       |
|----------------------|-------|
| Alkyd solution ..... | 19.50 |
|----------------------|-------|

|               |      |
|---------------|------|
| Butanol ..... | 3.00 |
|---------------|------|

|             |      |
|-------------|------|
| Xylol ..... | 3.00 |
|-------------|------|

|              |       |
|--------------|-------|
| Toluol ..... | 12.00 |
|--------------|-------|

100% b.w.

Total solids — 50.30%

Bake for 1 hour @ 250°F

Add driers as necessary

*Applied by spray gun***WHITE UREA — FORMALDEHYDE  
BAKING ENAMEL**

|                        |             |
|------------------------|-------------|
| Titanium dioxide ..... | 15.00% b.w. |
|------------------------|-------------|

|                  |      |
|------------------|------|
| Zinc oxide ..... | 5.00 |
|------------------|------|

|                            |       |
|----------------------------|-------|
| Urea resin (50% sol) ..... | 10.00 |
|----------------------------|-------|

*grind*

|                               |       |
|-------------------------------|-------|
| Castor oil alkyd (50% sol) .. | 11.00 |
|-------------------------------|-------|

|               |      |
|---------------|------|
| Butanol ..... | 3.00 |
|---------------|------|

|             |      |
|-------------|------|
| Xylol ..... | 3.00 |
|-------------|------|

|                  |       |
|------------------|-------|
| Urea resin ..... | 19.00 |
|------------------|-------|

|                        |       |
|------------------------|-------|
| C.O. alkyd resin ..... | 20.50 |
|------------------------|-------|

|               |      |
|---------------|------|
| Butanol ..... | 3.00 |
|---------------|------|

|                    |       |
|--------------------|-------|
| Hydrocarbons ..... | 10.50 |
|--------------------|-------|

100% b.w.

Total solids — 50.00%

Bake for 1 hour @ 250°F

*Applied by spray gun***WHITE ROLLER COAT BAKING  
ENAMEL**

|                 |             |
|-----------------|-------------|
| Titanox B ..... | 11.50% b.w. |
|-----------------|-------------|

|                 |       |
|-----------------|-------|
| Titanox C ..... | 30.70 |
|-----------------|-------|

*grind*

|                        |     |
|------------------------|-----|
| Ultramarine Blue ..... | .26 |
|------------------------|-----|

|                              |  |
|------------------------------|--|
| 10 gal. No. 801 amberol var- |  |
|------------------------------|--|

|            |       |
|------------|-------|
| nish ..... | 27.00 |
|------------|-------|

|                         |       |
|-------------------------|-------|
| Beckosol No. 1319 ..... | 27.00 |
|-------------------------|-------|

|                        |      |
|------------------------|------|
| Hi flash naphtha ..... | 3.02 |
|------------------------|------|

|                         |     |
|-------------------------|-----|
| Cobalt-zinc drier ..... | .52 |
|-------------------------|-----|

100% b.w.

Bake for 1 hour @ 250°F

*Applied by roller-coating and may also be  
applied by spray gun***NON-GELLING BRONZING LACQUER**

|                                |             |
|--------------------------------|-------------|
| 20 sec. Nitrocellulose (wet) . | 16.00% b.w. |
|--------------------------------|-------------|

|                      |       |
|----------------------|-------|
| Resin solution ..... | 15.00 |
|----------------------|-------|

|                   |      |
|-------------------|------|
| Plasticiser ..... | 5.00 |
|-------------------|------|

|                |       |
|----------------|-------|
| Acetates ..... | 25.00 |
|----------------|-------|

|                    |       |
|--------------------|-------|
| Hydrocarbons ..... | 21.00 |
|--------------------|-------|

|                |       |
|----------------|-------|
| Alcohols ..... | 18.00 |
|----------------|-------|

100% b.w.

*Dip or spray application*

**CLEAR BROOM HANDLE LACQUER**

|                                           |             |
|-------------------------------------------|-------------|
| $\frac{1}{2}$ second Nitrocellulose (wet) | 20.00% b.w. |
| Toluol .....                              | 15.00       |
| Ester gum .....                           | 44.00       |
| Butanol .....                             | 8.00        |
| Ethyl acetate .....                       | 13.00       |

100% b.w.

*Dip application. May also be spray coated which would involve a reduction of 1 to 4 (thinner)*

**WHITE BROOM HANDLE LACQUER**

|                                           |             |
|-------------------------------------------|-------------|
| $\frac{1}{2}$ second Nitrocellulose (wet) | 20.00% b.w. |
| Toluol .....                              | 10.00       |
| Titanium dioxide (dry) ....               | 25.00       |
| Denatured alcohol .....                   | 4.00        |
| Petroleum hydrocarbon .....               | 6.00        |
| Butylacetate .....                        | 4.00        |
| Ethyl acetate .....                       | 6.00        |
| Oil (plasticiser) .....                   | 25.00       |

100% b.w.

*Dip application. May also be spray coated, which would involve a reduction of 1 to 4 (thinner)*

**CLEAR CABLE LACQUER**

|                            |             |
|----------------------------|-------------|
| H.V. ethyl cellulose ..... | 13.63% b.w. |
| Hydrocarbons .....         | 62.32       |
| Alcohols .....             | 3.50        |
| Paraplex R.G. No. 2 .....  | 14.50       |
| B.B. castor oil .....      | 4.25        |
| White oil .....            | 1.80        |

100% b.w.

*Dip or squeegee coat application*

**LACQUER CEMENT**

|                              |             |
|------------------------------|-------------|
| Nitrocellulose base (C) .... | 87.00% b.w. |
| Plasticiser .....            | 9.00        |
| Acetates .....               | 4.00        |

100% b.w.

*May be spray coated or applied with knife or doctor blade*

**CEMENT - TILE**

|                               |             |
|-------------------------------|-------------|
| H.B. substitute shellac ..... | 55.00% b.w. |
| Castor oil .....              | 2.00        |
| Asbestos fibre .....          | 43.00       |

100% b.w.

*May be applied with knife or doctor blade*

**CLEAR CASKET LACQUER**

|                                           |             |
|-------------------------------------------|-------------|
| $\frac{1}{2}$ second Nitrocellulose (wet) | 30.00% b.w. |
| Hydrocarbons .....                        | 12.00       |
| Dammar-ester solutions .....              | 32.00       |
| Acetates .....                            | 22.00       |
| Plasticiser .....                         | 4.00        |

100% b.w.

*Spray gun application*

**CERAMIC LACQUER**

|                              |             |
|------------------------------|-------------|
| Nitrocellulose base (C) .... | 26.00% b.w. |
| Dammar resin solution .....  | 34.00       |
| Acetates .....               | 12.00       |
| Hydrocarbons .....           | 26.00       |
| Alcohol .....                | 2.00        |

100% b.w.

*Use paste colors, 1 $\frac{1}{2}$  pounds per gallon  
Spray gun application*

**BLACK CRACKLE LACQUER**

|                              |             |
|------------------------------|-------------|
| Nitrocellulose base (C) .... | 42.00% b.w. |
| Resin solution (dammar) ...  | 6.00        |
| Hydrocarbons .....           | 22.00       |
| Acetates .....               | 12.00       |
| Alcohols .....               | 18.00       |
| Monarch 71 (carbon black)    | 6.00        |

100% b.w.

*Disperse in ball mill  
Spray gun application*

**CLEAR DECALCOMANIA LACQUER**

|                              |             |
|------------------------------|-------------|
| Nitrocellulose base (A) .... | 34.00% b.w. |
| Resin solution .....         | 12.00       |
| Hydrocarbons .....           | 28.00       |
| Acetates .....               | 21.00       |
| Alcohols .....               | 3.50        |
| Plasticiser .....            | 1.50        |

100% b.w.

*Spray gun or roller coat application*

**CLEAR DIPPING LACQUER**

|                              |             |
|------------------------------|-------------|
| Nitrocellulose base (C) .... | 49.00% b.w. |
| Ester gum solution .....     | 17.00       |
| Acetates .....               | 4.00        |
| Hydrocarbons .....           | 25.00       |
| Alcohols .....               | .50         |
| Plasticiser .....            | 4.50        |

100% b.w.

*Dip application. May be sprayed, using  
1 to 4 (thinner) reduction*

**CLEAR LACQUER EMULSION\***

|                              |             |
|------------------------------|-------------|
| 5 sec.-6 sec. Nitrocellulose |             |
| lose (dry) .....             | 17.00% b.w. |
| Ester gum .....              | 13.00       |
| Dibutyl phthalate .....      | 4.00        |
| <i>lacquer phase</i>         |             |
| Butyl alcohol .....          | 16.50       |
| H.F. naphtha .....           | 16.50       |
| s-hexyl acetate .....        | 16.50       |
| Octyl acetate .....          | 16.50       |
| Water .....                  | 78.50       |
| Duponol ME (dry) .....       | .50         |
| <i>water phase</i>           |             |
| Sulphonated castor oil ..... | 1.00        |
|                              | <u>100%</u> |

*Spray coat application*

\*Hercules Powder Co.

**CLEAR FISH LINE COATING**

|                              |                  |
|------------------------------|------------------|
| Nitrocellulose base (C) .... | 35.00% b.w.      |
| Oil (plasticiser) .....      | 11.00            |
| Acetates .....               | 21.00            |
| Hydrocarbons .....           | 33.00            |
|                              | <u>100% b.w.</u> |

*Dip or squeegee application***CLEAR FLEXIBLE LACQUER**

|                               |                  |
|-------------------------------|------------------|
| Nitrocellulose base (A) ..... | 97.00% b.w.      |
| Plasticiser .....             | 3.00             |
|                               | <u>100% b.w.</u> |

*Use paste colors, 1½ pounds per gallon*  
*Spray gun application*

**CLEAR LABEL VARNISH**

|                           |                  |
|---------------------------|------------------|
| Manila chips in D.A. .... | 82.00% b.w.      |
| No. 15 castor oil .....   | 1.80             |
| V.M. & P. Naphtha .....   | 16.20            |
|                           | <u>100% b.w.</u> |

*Roller coat application***CLEAR MANTLE DIP**

|                                  |                  |
|----------------------------------|------------------|
| ½ second Nitrocellulose (wet) .. | 12.00% b.w.      |
| Denatured alcohol .....          | 61.00            |
| Ethyl acetate .....              | 27.00            |
|                                  | <u>100% b.w.</u> |

*Dip application***NITROCELLULOSE BASE (A)**

|                                  |                  |
|----------------------------------|------------------|
| ½ second Nitrocellulose (wet) .. | 43.00% b.w.      |
| Acetates .....                   | 40.00            |
| Hydrocarbons .....               | 13.00            |
| Alcohols .....                   | 4.00             |
|                                  | <u>100% b.w.</u> |
| Total solids — 30%               |                  |

**NITROCELLULOSE BASE (B)**

|                                  |                  |
|----------------------------------|------------------|
| ½ second Nitrocellulose (wet) .. | 43.00% b.w.      |
| Acetates .....                   | 40.00            |
| Hydrocarbons .....               | 13.00            |
| Alcohols .....                   | 4.00             |
|                                  | <u>100% b.w.</u> |
| Total solids — 30%               |                  |

**NITROCELLULOSE BASE (C)**

|                                                     |                  |
|-----------------------------------------------------|------------------|
| 15 second-20 second Nitro-<br>cellulose (wet) ..... | 21.20% b.w.      |
| Acetates .....                                      | 33.80            |
| Alcohols .....                                      | 9.00             |
| Hydrocarbons .....                                  | 36.00            |
|                                                     | <u>100% b.w.</u> |
| Total solids — 14.80%                               |                  |

**CLEAR PAPER LACQUER**

|                                  |                  |
|----------------------------------|------------------|
| ½ second Nitrocellulose (wet) .. | 16.63% b.w.      |
| Butyl acetate .....              | 26.00            |
| Dammar solution .....            | 19.10            |
| Dibutyl phthalate .....          | 8.77             |
| Toluol .....                     | 29.50            |
|                                  | <u>100% b.w.</u> |

Total solids — 29.16%

*Coating machine (roller) application***CARBON BLACK LACQUER PASTE**

|                                 |                  |
|---------------------------------|------------------|
| Carbolac No. 2 .....            | 4.00% b.w.       |
| Castor oil .....                | 40.00            |
| Dibutyl phthalate .....         | 12.00            |
| 50% No. 801 amberol solution .. | 44.00            |
|                                 | <u>100% b.w.</u> |
| Total solids — 78%              |                  |

**CLEAR METAL LACQUER**

|                              |                  |
|------------------------------|------------------|
| Nitrocellulose base (C) .... | 26.00% b.w.      |
| Hydrocarbons .....           | 35.00            |
| Acetates .....               | 28.50            |
| Plasticiser .....            | 1.50             |
| Resin solution .....         | 10.00            |
|                              | <u>100% b.w.</u> |

*Spray application*

# CLEAR ROLLER COATING LACQUER

|                                 |             |
|---------------------------------|-------------|
| Nitrocellulose Base (A) . . . . | 39.00% b.w. |
| Resin solution . . . . .        | 19.00       |
| H.B. acetates . . . . .         | 18.00       |
| Plasticiser . . . . .           | 6.00        |
| Hydrocarbons . . . . .          | 18.00       |
|                                 | <hr/>       |
|                                 | 100% b.w.   |

*Roller coating application*

# STRIPING LACQUER

|                                 |             |
|---------------------------------|-------------|
| Nitrocellulose base (A) . . . . | 52.00% b.w. |
| Resin solution . . . . .        | 12.00       |
| Acetates . . . . .              | 14.00       |
| Hydrocarbons . . . . .          | 10.00       |
| Plasticiser . . . . .           | 2.00        |
| Alcohols . . . . .              | 10.00       |
|                                 | <hr/>       |
|                                 | 100% b.w.   |

*Use paste colors, 3 pounds per gallon  
Brush application*

# HI-GLOSS SYNTHETIC ENAMEL (BLACK)

|                                |            |
|--------------------------------|------------|
| Carbolac No. 20 . . . . .      | 4.00% b.w. |
| Beckosol No. 1 . . . . .       | 47.00      |
| <i>grind</i>                   |            |
| Solvesso No. 3 . . . . .       | 3.00       |
|                                | <hr/>      |
| Beetle resin No. 227-8 . . . . | 15.50      |
| Rezyl No. 807 . . . . .        | 15.50      |
| Solvesso No. 3 . . . . .       | 6.00       |
| Xylol . . . . .                | 9.00       |
|                                | <hr/>      |
|                                | 100% b.w.  |

Total solids — 43%  
Bake for 1 hour at 250°F  
Add driers as necessary  
*Spray gun application*

# SYNTHETIC RESIN VEHICLE

|                                |             |
|--------------------------------|-------------|
| Glycerine . . . . .            | 22.00% b.w. |
| Phthalic anhydride . . . . .   | 41.00       |
| L.O. fatty acids . . . . .     | 30.00       |
| Wecoline fatty acids . . . . . | 7.00        |
|                                | <hr/>       |
|                                | 100% b.w.   |

Run to 475°F for 2½ hours — pull and  
stand for 1 hour; reduce with H.F.  
naphtha and mineral spirits

# MEDIUM GREEN SILK SCREEN SYNTHETIC PASTE (SIGN FINISHES)

|                                 |             |
|---------------------------------|-------------|
| Lt. Ch. Green . . . . .         | 22.00% b.w. |
| Surfex . . . . .                | 6.00        |
| <i>grind</i>                    |             |
| Barytes . . . . .               | 16.00       |
| L.O. alkyd resin (65% T.S.)     | 25.20       |
|                                 | <hr/>       |
| Alkyd resin . . . . .           | 21.80       |
| Pb. Co. Mn. drier . . . . .     | 3.00        |
| Double boiled linseed oil . . . | 6.00        |
|                                 | <hr/>       |
|                                 | 100% b.w.   |

*Press-Print or squeegee application*

# BLACK SILK SCREEN SYNTHETIC PASTE (SIGN FINISHES)

|                               |            |
|-------------------------------|------------|
| Monarch No. 71 . . . . .      | 2.25% b.w. |
| Surfex . . . . .              | 5.00       |
| Barytes . . . . .             | 12.00      |
| <i>grind</i>                  |            |
| L.O. alkyd resin (75% T.S.)   | 35.40      |
| 4 hr. linseed oil . . . . .   | 3.50       |
| Co. linoleate drier . . . . . | 1.85       |
|                               | <hr/>      |
| Alkyd resin . . . . .         | 37.00      |
| Pb. Co. Mn. drier . . . . .   | 3.00       |
|                               | <hr/>      |
|                               | 100% b.w.  |

Total solids — 77%

*Press-Print or squeegee application*

# CLEAR WOOD SEALER

|                                 |            |
|---------------------------------|------------|
| Zinc stearate . . . . .         | 1.79% b.w. |
| 18-23 cp. nitrocellulose (wet)  | 10.80      |
| Acetates . . . . .              | 25.90      |
| Hydrocarbons . . . . .          | 24.80      |
| Alcohols . . . . .              | 7.11       |
| Cocoonut oil syn. resin . . . . | 29.60      |
|                                 | <hr/>      |
|                                 | 100% b.w.  |

Total solids — 24.14%  
*Spray gun application*

# LACQUER THINNER

|                        |             |
|------------------------|-------------|
| Hydrocarbons . . . . . | 60.00% b.w. |
| Acetates . . . . .     | 30.00       |
| Alcohols . . . . .     | 10.00       |
|                        | <hr/>       |
|                        | 100% b.w.   |

**TOY LACQUER**

|                                 |             |
|---------------------------------|-------------|
| Nitrocellulose base (C) . . . . | 12.50% b.w. |
| Acetates . . . . .              | 25.00       |
| Hydrocarbons . . . . .          | 50.00       |
| 20 pound ester gum solution     | 12.50       |

100% b.w.

*Use paste colors, 1½ pounds per gallon  
Spray or dip application*

**TUMBLING LACQUER**

|                                 |            |
|---------------------------------|------------|
| 4 second Nitrocellulose (wet)   | 9.00% b.w. |
| Nitrocellulose base (A) . . . . | 3.00       |
| Resin solution (dammar) . . .   | 38.00      |
| Hydrocarbons . . . . .          | 29.00      |
| Acetates . . . . .              | 23.00      |
| Alcohols . . . . .              | 7.00       |

100% b.w.

*Use paste colors, 4 pounds per gallon  
Dip or Tumble application*

**WHITE VENETIAN BLIND LACQUER**

|                               |             |
|-------------------------------|-------------|
| ½ second Nitrocellulose (wet) | 23.00% b.w. |
| Titanium dioxide . . . . .    | 16.00       |
| Hydrocarbons . . . . .        | 23.00       |
| Alcohols . . . . .            | 9.00        |
| Acetates . . . . .            | 13.00       |
| Dibutyl phthalate . . . . .   | 3.40        |
| Blown castor oil . . . . .    | 12.60       |

100% b.w.

*Roller coat application*

**CLEAR WOOD LACQUER**

|                               |            |
|-------------------------------|------------|
| 6 second Nitrocellulose (wet) | 5.07% b.w. |
| Plasticiser . . . . .         | 1.53       |
| No. 2 Lewisol resin . . . . . | 14.70      |
| Acetates . . . . .            | 25.10      |
| Hydrocarbons . . . . .        | 43.15      |
| Alcohols . . . . .            | 10.45      |

100% b.w.

**Total solids — 21.78%**

*Spray application*

**CLEAR WOOD LACQUER**

|                               |            |
|-------------------------------|------------|
| ½ second Nitrocellulose (wet) | 7.00% b.w. |
| Plasticiser . . . . .         | 5.00       |
| Hard resin . . . . .          | 5.00       |
| Plastic resin . . . . .       | 2.00       |
| Semiplastic resin . . . . .   | 2.00       |
| Acetates . . . . .            | 37.50      |
| Cyclic hydrocarbons . . . . . | 41.50      |

100% b.w.

**Total solids — 21%**

*Spray application*

**CLEAR WOOD LACQUER**

|                                 |             |
|---------------------------------|-------------|
| Nitrocellulose base (A) . . . . | 20.00% b.w. |
| Nitrocellulose base (B) . . . . | 10.00       |
| Dammar resin solution . . . . . | 14.13       |
| 8 pound shellac cut . . . . .   | 6.04        |
| Plasticiser . . . . .           | 1.00        |
| Paraplex RG No. 2 . . . . .     | 1.70        |
| Hydrocarbon . . . . .           | 25.83       |
| Alcohols . . . . .              | 11.00       |
| Acetates . . . . .              | 10.20       |

100% b.w.

**Total solids — 21%**

*Spray application*

**BLACK WRINKLE FINISH**

|                         |            |
|-------------------------|------------|
| Supercarbovar . . . . . | 1.10% b.w. |
| Inert pigment . . . . . | 46.40      |
| Resin varnish . . . . . | 41.00      |
| Hydrocarbon . . . . .   | 11.50      |

100% b.w.

**Bake for 1 hour @ 250°F**

*Spray application*

**REFERENCES**

(11) See paper entitled "Prevention of gelling of bronze powders," Bogen, Kelly and Maroney, *Ind and Eng. Chemistry*, Sept. 1931.

(12) See paper, "A study of the gelling of bronze lacquers and its prevention" — Hercules Powder Company — 1934.

## PART III

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### CHAPTER IX

#### ANALYTICAL METHODS · LABORATORY AND FIELD TESTS

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The true value of a coating material lies in its ability to withstand the elements, its abuse through use, and its retention of form, color, gloss, etc., after the surface on which it has been applied has been in service.

One of the fundamental requisites of the merchandising value of coating material is quality. Properties and resistance before and during use are important and the pretesting before marketing is of great importance.

Materials are tested for various characteristics relating to its structure and under comparable conditions of application used by industry.

The following laboratory control and field tests are applicable to lacquer and synthetic enamel finishes:

#### **Maintain Standard Sample**

Whenever a raw material is to be used in the manufacture of lacquer or synthetic enamel, it is first approved by the control laboratory and a standard sample is adopted as a master standard. Succeeding shipments of raw materials are checked against this master standard and as each of the standards are depleted through checking, it is replenished from an approved shipment.

Nitrocellulose is very rarely, if ever, maintained as a standard sample, except for color and grainy appearance. If nitrocellulose is retained with raw material standards, care should be exercised to see that the alcohol (used as a wetting liquid) does not evaporate. Mason



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jars with double rubber gaskets and tight fitting lids should be used and the jars should be placed on their sides rather than on end, which will allow for an even distribution of the alcohol. If more than one manufacturer's lot number is received in a single shipment, a composite sample of the lot may be retained. As soon as any complete lot is used in manufacture, the retained sample should be used for manufacturing purposes and a new sample retained as a standard. Nitrocellulose is customarily retained as a base solution, e.g., 16, 24, or 48 ounce solution. Such solutions are retained in wide-mouth glass bottles, fitted with tight stoppers.

Resins are retained in their bold or plastic state and are retained in wide mouth bottles, fitted with tight stoppers.

Plasticisers and solvents are retained in dark colored and tight stoppered bottles.

Pigment standards are retained in wide mouth glass containers. They are likewise maintained on glass slides. Pigments are rubbed in oil on a glass rubbing base and transferred to these slides. Three color groups appear on each slide: one showing full strength, one letdown 25% with zinc oxide and one a 50% letdown with zinc oxide. These slides are kept as a permanent record in a specially prepared wooden rack that is fitted with grooved slots to hold the glass slides. A sprayed panel of the ground pigment paste in a standard nitrocellulose base is likewise retained. Such retains are kept on a metal panel, 4" X 8".

Standard samples of both raw material and finished products should be kept in a special building away from the manufacturing operations. This building should be equipped with a shelf space suitable for the storage of such samples. The building should be out of contact with such elements as heat, light, dust and air, as these factors cause evaporation, deterioration, and general disintegration of materials of this type.

A one quarter gallon standard sample is retained of a newly developed product. Such a sample is "set-up" as a master standard for that particular development. When a lacquer manufacturer has a large account, e.g., a motor car manufacturer, it is often advisable to maintain standard samples of newly developed products both at the manufacturing unit and at the account's laboratory. Succeeding batches of regular industrial items are retained in 1-16 gallon sizes.

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All standards should be suitably labeled, showing a batch number as well as the formula number and date of manufacture. As retained samples increase in number, the older samples are replaced and are used in newly manufactured material. A 4"  $\times$  8" sprayed metal panel is retained of each newly manufactured colored material and is set-up as a master standard panel. A smaller 2"  $\times$  4" metal panel or 3"  $\times$  6" panel is also retained of succeeding batches. These panels are filed for future reference and against any possible color complaint. A standard retain panel of succeeding batches (3"  $\times$  6") as filed, has half of the panel appearing in spray from the one quarter gallon master standard and the other half of the panel appearing in spray from the approved batch. Clear lacquers are retained on polished brass or on a wooden panel, as the particular type may indicate.

Retained master standard samples of clear finishes are kept in a glass container, while the 1-16 gallon batch standards are retained in tin containers.

The laboratory office is responsible for tabulating all formulae of lacquers, etc., to be manufactured by the plant. The following card is used, which is made in duplicate.

Product.....

| Customer..... | Formula Number..... |
|---------------|---------------------|
|---------------|---------------------|

[illegible]

Mixer No. .... Mill No. .... Tank No. .... Clarifier ..

| Std. Wt. Gal. | Actual Wt. Gal. | Std. Yield | Actual Yield |
|---------------|-----------------|------------|--------------|
|---------------|-----------------|------------|--------------|

[illegible]

|                      |           |                   |
|----------------------|-----------|-------------------|
| Goods to Be Reworked | Left Over | Gals.....Lbs..... |
|----------------------|-----------|-------------------|

| Code No. | Prod. No. | Size | Quantity | Amounts Used in Other Productions |      |          |                |
|----------|-----------|------|----------|-----------------------------------|------|----------|----------------|
|          |           |      |          | Gals.                             | Lbs. | Code No. | Production No. |
|          |           |      |          |                                   |      |          |                |
|          |           |      |          |                                   |      |          |                |
|          |           |      |          |                                   |      |          |                |

**Fineness of Grind..... Mix..... Grind Std. Time.....**

**Cooking Std. Time.....Thinning.....Tinting.....**

**Clarifier**.....

**Cloth Filter**.....

**Filter Presses.....**

Approved By.....Date Completed.....19.....

Both copies go to the plant who indicate in writing (a carbon copy is attached) the amounts used. The formula is returned to the office when the batch is filled, one copy is filed and the original is turned over to the cost department for accounting purposes.

The filling instructions contain disposition of the material and are placed with the filled containers that are turned over to stock. The original is returned to the stock clerk for perpetual inventory. The batch sample slip is attached to the retained sample of the batch and filed.

#### FILLING INSTRUCTIONS

| Size of<br>Pkg.       | Drum | Bbl.     | 5 gal.  | 1 gal.  | $\frac{1}{2}$ gal. | $\frac{1}{4}$ gal. | $\frac{1}{8}$ gal. | $\frac{1}{16}$ gal. | $\frac{1}{32}$ gal. |
|-----------------------|------|----------|---------|---------|--------------------|--------------------|--------------------|---------------------|---------------------|
|                       |      | 100 lbs. | 50 lbs. | 25 lbs. | 12½ lbs.           | 5 lbs.             | 1 lb.              | $\frac{1}{2}$ lb.   | $\frac{1}{4}$ lb.   |
| Number<br>Wanted      |      |          |         |         |                    |                    |                    |                     |                     |
|                       |      |          |         |         |                    |                    |                    |                     |                     |
| Number<br>Filled      |      |          |         |         |                    |                    |                    |                     |                     |
|                       |      |          |         |         |                    |                    |                    |                     |                     |
| Container<br>Code No. |      |          |         |         |                    |                    |                    |                     |                     |
|                       |      |          |         |         |                    |                    |                    |                     |                     |

Filling Completed.....19.....By.....

Disposition of Left Over.....

#### Laboratory Control

As each new product is developed, a card record is maintained in the control laboratory files. This card indicates various tests and characteristics of each individual product. This close control will minimize complaints as each product is formulated to meet some specific condition met with in its normal use.

Periodically the laboratory will check the manufacturing unit on some individual product for all of the characteristics noted on this card, which is in addition to tests as conducted for control purposes. Retained standard samples are likewise periodically checked.

The following form card is used for these periodic check-ups:

## LABORATORY INSPECTION AND DEVELOPMENT

Formula No. \_\_\_\_\_ Panel No. \_\_\_\_\_

Production No. \_\_\_\_\_ Gals. \_\_\_\_\_ Date \_\_\_\_\_

Customer \_\_\_\_\_

1. Type of Grind \_\_\_\_\_
2. Number of Grinds \_\_\_\_\_
3. Viscosity \_\_\_\_\_ Temp. \_\_\_\_\_ Deg. \_\_\_\_\_
4. Make of Viscosimeter \_\_\_\_\_
5. Odor \_\_\_\_\_
6. Specific Gravity \_\_\_\_\_
7. Miscibility (in Thinners) \_\_\_\_\_ in Lacquers \_\_\_\_\_
8. Can Condition \_\_\_\_\_ Settling \_\_\_\_\_
9. Thinning Required for Use \_\_\_\_\_
10. Working: Brush \_\_\_\_\_ Spray \_\_\_\_\_ Dip \_\_\_\_\_
11. Type of Air Gun \_\_\_\_\_ Air Pressure \_\_\_\_\_ Lbs. Per Sq. In. \_\_\_\_\_
12. Hiding (Opacity) \_\_\_\_\_ No. of Coats \_\_\_\_\_
13. Leveling \_\_\_\_\_ Orange Peel \_\_\_\_\_ Lifting \_\_\_\_\_
14. Drying: To Touch \_\_\_\_\_ Hardened \_\_\_\_\_
15. Baking \_\_\_\_\_ Hrs. at Temp. \_\_\_\_\_ Deg. " F " \_\_\_\_\_
16. Hardness \_\_\_\_\_ Toughness \_\_\_\_\_ Elasticity \_\_\_\_\_
17. Filling \_\_\_\_\_ Surfacing \_\_\_\_\_ Adhesion \_\_\_\_\_
18. Finish: Gloss \_\_\_\_\_ Dull \_\_\_\_\_ Flat \_\_\_\_\_ Semi Flat \_\_\_\_\_
19. Blushing \_\_\_\_\_ Blooming \_\_\_\_\_
20. Color vs. Standard \_\_\_\_\_ Bleeding \_\_\_\_\_
21. Sanding \_\_\_\_\_ Rubbing \_\_\_\_\_ Polishing \_\_\_\_\_
22. Abrasive Used \_\_\_\_\_
23. Brilliancy After Polishing \_\_\_\_\_
24. Accelerated Weathering Test \_\_\_\_\_

General Remarks \_\_\_\_\_

Signed \_\_\_\_\_

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## WORKING TEST

### Sprayability

The ability of a coating material to be handled properly by spray application is associated with viscosity or body, its amount of reduction with the proper reducer and the miscibility or tolerance with that liquid. With proper spray equipment, proper reduction and proper reducer, a material may be considered exacting when a smooth, level, gloss-like film is secured.

### Miscibility

The miscibility or ability of a reducer-thinner or of a second material to become intermixed should be determined in a small way before any attempt to admix a larger volume. Some materials have a greater tolerance for certain liquids and this fact should be determined beforehand. Lacquer materials and synthetic enamels should be reduced-thinned with a volatile solvent or combination of volatile liquids as recommended by the supplier. The influence of a greater proportion of a petroleum hydrocarbon to the liquid ester content (in lacquers) will disturb the ability to secure proper spraying results.

### Odor

Benzol and similar toxic liquids are sharp and if present will produce a nauseating effect. A simple test is the smell test and an apt nose will detect the difference between materials. In reducer-thinner detections, a pour on a blotter or filter paper will, by captivating the liquid, permit a prolonged "smell-test." All sharp odors, however, are not toxic.

## ANALYTICAL METHODS APPLICABLE TO LACQUERS AND ALLIED PRODUCTS

### Solvents

(a) **SAPONIFICATION** — Weigh about 1.5 g of the solvent (.001) in a 250 cc. Erlenmeyer flask. Add 50 cc. alcoholic KOH solution from a burette and place on a reflux condenser to boil for one hour. Remove, thoroughly cool, add phenolphthalein as an indicator and titrate with  $n/2$  HCl. Blank determinations should be run with the alcoholic sodium hydroxide solution and should check within 0.1 cc.  $n/2$  HCl.

From the difference between the number of cubic centimeters of  $n/2$  HCl required for the blank and for the determination, the saponification (mg. KOH per gram of liquid) is calculated.

(b) DRYNESS — To 5 cc. of solvent in a 100 cc. graduate add successive 10 cc. portions of naphtha with thorough mixing between each addition until first cloudiness appears. Express results in ratio form, i.e.,

O.K. @ 1-3, etc.

(c) ACIDITY — (1) Immerse a strip of blue litmus paper in the liquid and allow it to remain for thirty minutes. Note any change in color of the paper.

(2) Place a small amount (10 cc.) of the sample in a measuring cylinder and fill with hot distilled water. Add a few drops of methyl orange solution, shake thoroughly and set aside to separate. Red color in aqueous layer indicates acid.

(3) Titrate 10 cc. of the sample with  $n/10$  alcoholic KOH using phenolphthalein as the indicator and calculate as follows:

$$\frac{\% \text{CH}_3\text{COOH} = \text{titre} \times \text{normality} \times .06004}{10 \times \text{specific gravity}}$$

(d) WATER SOLUBILITY — Shake 10 cc. of solvent with 15 cc. of saturated NaCl solution in a 25 cc. flask and note the volume of oily layer after settling or measure into a 50 cc. color carbon tube, 25 cc. of  $\text{H}_2\text{O}$  and 25 cc. of solvent. Mix by repeated immersion and set aside until separated into layers and read at the line of separation in cubic centimeters. Calculate as follows:

$$\text{H}_2\text{O solubility} = 5 \text{ cc.} = \text{reading } 10\%$$

(e) SULPHURIC ACID SOLUBILITY — Mix equal portions of the solvent to be tested with conc.  $\text{H}_2\text{SO}_4$ . Note the color of the resultant mixtures.

(f) DISTILLATION — The flask shall be a standard Engler flask. Gasoline shall be distilled in a flask of 100 cc. capacity, while all other distillations shall be made in a flask of 250 cc. capacity. All apparatus used in distillation and the method of distillation shall be in compliance with the A.S.T.M. standard method, serial designation D-86-27.

*Method of Distillation* — Place 100 cc. of solvent in the flask. The material is measured with a 100 cc. receiving cylinder at 60° F. The flask is connected with the condenser and rests on a wire gauge and an asbestos mat with a hole 3–4" in diameter in which the bottom of the flask may rest. The flask is heated directly with a Meeker type burner and the flame is so adjusted that the tip of the inner cone is just below the wire gauge. Distillation shall proceed at the rate of not less than 4 or more than 5 cc. per minute into the receiving cylinder. Collect the distillate in a 25 cc. cylinder, changing cylinders so that 4 fractionations of 25 cc. each are obtained and note the odors. The temperature at which the first drop leaves the lower end of the condenser shall be considered the initial boiling point. Take the temperature readings at 2 cc., 5 cc., and at 5 cc. intervals to 90 cc. then at 92 cc., 95 cc. and the last reading obtainable (dry). Note the odor of the residue in the flask. The total yield of the distillate shall not be less than 97%.

(g) *SPECIFIC GRAVITY* — The specific gravity is determined by means of a pycnometer at 20° C. Fill with the liquid, place in a water bath, and bring it to the desired temperature. When the bottle and contents are at the bath temperature, insert the stopper and remove the surplus liquid from the outside of the bottle with a clean cloth and weigh. The weight of the bottle when empty and the weight of the water it holds must also be determined and at the same temperature at which the specific gravity was made. Calculate as follows:

$w$  = weight of bottle plus liquid

$w_2$  = weight of bottle plus water

$w_3$  = weight of bottle (empty)

$$\text{Sp. Gr.} = \frac{w - w_3}{w_2 - w_3}$$

For plant control purposes among the users of lacquers, the specific gravity of the lacquer being used should be held to a rigid control. This gravity is determined by the use of a hydrometer. The hydrometer is a glass spindle bearing a scale for reading purposes, and is weighted at one end. The scale may appear in terms of specific gravity or as is most generally the case, in degrees of Baumé. There



are two Baumé scales, one is used for liquids which are lighter than water, and the other for liquids which are heavier than water.

The method of determining the specific gravity of the lacquer is to immerse the hydrometer into the lacquer. The spindle will sink to a mark on the scale and the scale reading is obtained at the point where the spindle emerges from the lacquer. The lighter the liquid, the deeper the spindle will sink and the heavier the liquid, the less the penetration. Hydrometer readings indicate the weight of a gallon of lacquer as compared to the weight of a gallon of water. Clear lacquer of spraying body (wood lacquer) and reducers are lighter than water and the so-called "coal oil" hydrometer should be used. Colored lacquers are heavier than water and the "acid" hydrometer should be used.

Generally speaking, pigmented and metal finishing lacquers require reductions; which in most instances involve equal volumes of thinner. The use of thinners purchased from different sources, other than the manufacturer of the lacquer being used, has indicated that a Baumé test of lacquers should be run. The above statement may be explained by the following, "it is always considered a good policy to use thinners and lacquers from one and the same manufacturer in order to insure entire compatibility one with the other. If an equal volume of thinner is recommended, such a thinner is compounded on the formula of the particular lacquer, therefore satisfactory results may be expected." Hydrometer readings will vary with the specific gravity of the thinner used, even though the viscosity of the lacquer (before reduction) is established. This has further bearing on the use of thinner recommended by the manufacturer of the lacquer, and will influence proper consistency, dispersion, surface tension effects, and definite film thickness at applying pressures.

This gravity should not be confused with viscosity. The specific gravity or Baumé reading is an expression of the relative weight of a known volume as compared to the weight of the same volume of pure water at a given temperature. The viscosity is a measure of the material to the relative flow of its particles. These factors are independent of each other and represent different qualities of a lacquer.

Baumé readings may be converted into specific gravity readings through a handy conversion chart available from numerous sources.

(A specific gravity conversion chart is illustrated, see illustration No. 32.)

(h) DILUTION RATIO — This test is run on esters. Six grams of dry  $\frac{1}{2}$  second nitrocellulose is dissolved in 50 cc. of the liquid ester to be tested. When the solution is complete, it is titrated with toluol or benzol until the nitrocellulose is precipitated. While this titration is being made, the flask should be agitated constantly, otherwise the

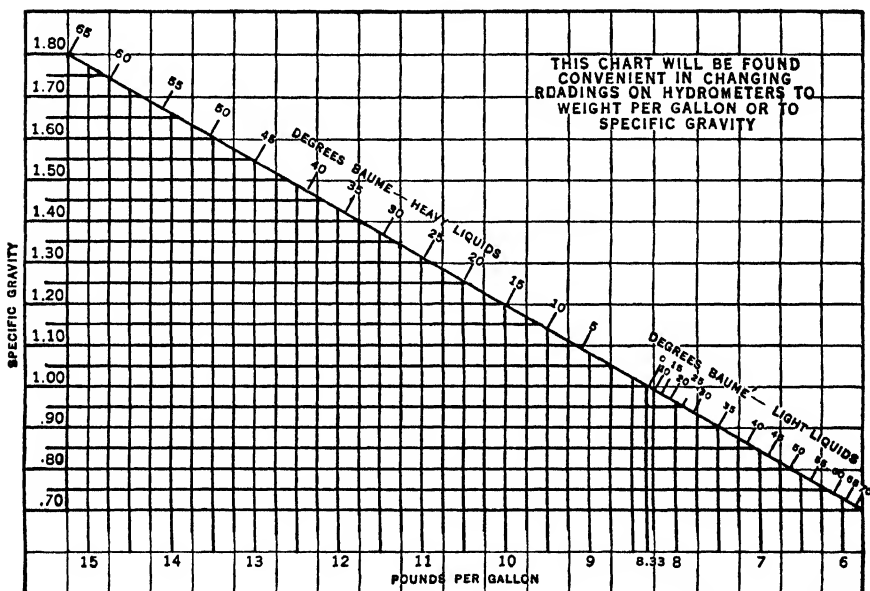


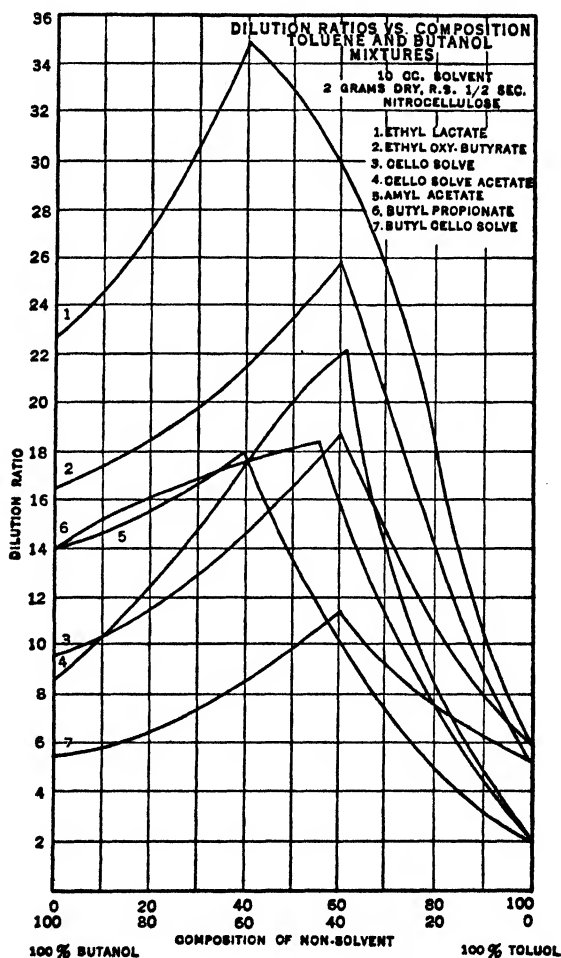
FIG. 32. Specific gravity conversion chart

nitrocellulose will be precipitated in hard and difficult soluble lumps. Toward the end of the titration, the toluol or benzol should be added slowly and the solution agitated after each addition. The end point is reached when the nitrocellulose will no longer go into solution. The dilution ratio is the figure obtained by dividing the cubic centimeters of toluol or benzol used for titration by the 50 cc. of the ester used to dissolve the nitrocellulose. (Illustrations No. 33 and No. 34 show the dilution ratio of several commonly used solvents.)

The dilution ratios of several solvents were determined using toluol, dryoline No. 300, and butanol as the diluents. Dilution ratios

with an alcohol were worthy of note and the influence of adding small percentages to a hydrocarbon is quite marked.

Two gram portions of  $\frac{1}{2}$  second nitrocellulose (dry) were dissolved



*Amer. Cyanamid Co.*

FIG. 33. Dilution ratio

in 20 cc. of the solvent, and diluted until the nitrocellulose was precipitated. Data are given for each of the three diluents when used alone and for diluent mixtures: butanol, toluol and butanol, and dryoline.

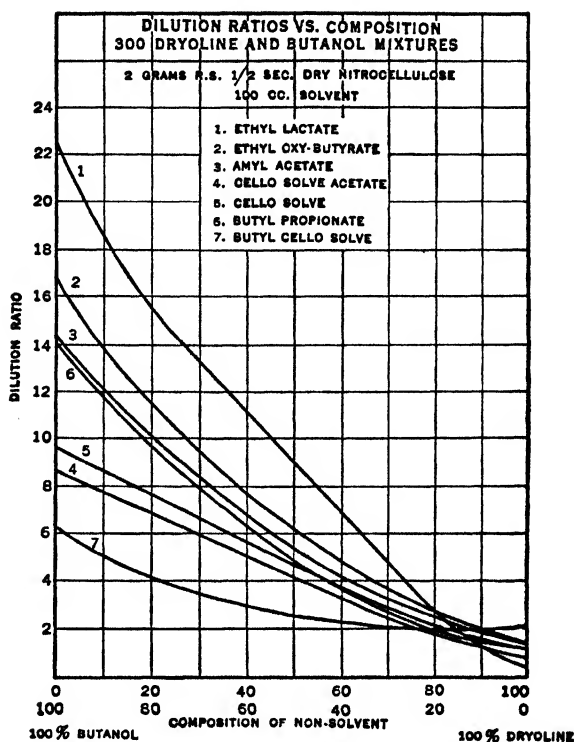


FIG. 34. Dilution ratio

*Amer. Cyanamid Co.***DILUENT MIXTURE**

| Solvent                 | % butanol | 0    | 20   | 40   | 60   | 80   | 100 |
|-------------------------|-----------|------|------|------|------|------|-----|
|                         | % toluol  | 100  | 80   | 60   | 40   | 20   | 0   |
| Ethyl lactate.....      | 6.0       | 18.0 | 30.0 | 35.0 | 27.0 | 22.5 |     |
| Cellosolve.....         | 6.0       | 11.0 | 19.0 | 15.0 | 11.0 | 9.5  |     |
| Cellosolve acetate..... | 2.5       | 8.5  | 22.0 | 18.0 | 12.5 | 8.5  |     |
| Butyl propionate.....   | 2.0       | 7.5  | 16.0 | 17.5 | 16.0 | 14.0 |     |
| Amyl acetate.....       | 2.0       | 5.0  | 10.0 | 18.0 | 15.5 | 14.0 |     |
| Butyl cellosolve.....   | 5.2       | 7.4  | 11.6 | 8.5  | 6.0  | 5.8  |     |

**DILUENT MIXTURE**

| Solvent                 | % butanol  | 0   | 20  | 40   | 60   | 80   | 100 |
|-------------------------|------------|-----|-----|------|------|------|-----|
|                         | % dryoline | 100 | 80  | 60   | 40   | 20   | 0   |
| Ethyl lactate.....      | 0.5        | 2.3 | 7.0 | 10.8 | 15.5 | 22.5 |     |
| Cellosolve.....         | 1.0        | 2.0 | 4.2 | 5.4  | 7.2  | 9.5  |     |
| Cellosolve acetate..... | 0.8        | 1.7 | 3.2 | 5.0  | 7.0  | 8.5  |     |
| Butyl propionate.....   | 1.0        | 3.0 | 3.8 | 6.0  | 9.5  | 14.0 |     |
| Amyl acetate.....       | 1.5        | 2.6 | 4.8 | 6.6  | 10.0 | 14.0 |     |
| Butyl cellosolve.....   | 2.0        | 2.1 | 2.1 | 3.8  | 4.2  | 5.8  |     |

(i) **TOLERANCE** — A tolerance test is run on lacquer diluents. Six grams of dry  $\frac{1}{2}$  second nitrocellulose is dissolved in 50 cc. of ethyl acetate or a nitrocellulose base of known structure may be used. Solution is titrated with the diluent to be tested; the end point being taken as the point when the nitrocellulose will no longer go into solution with additions of the diluent. The tolerance is the figure



FIG. 35. Blush test

obtained by dividing the cubic centimeters of the diluent used for titration by the 50 cc. of ethyl acetate used to dissolve the nitrocellulose or nitrocellulose base.

(j) **PYRIDINE IN ALCOHOL** — Five cubic centimeters of the alcohol is added to 20 cc. of a 10% solution of cadmium chloride in a 2 oz. bottle, well shaken for 5 minutes and allowed to stand for 30 minutes. If no white flocculent precipitate has formed in that time, the alcohol contains no pyridine.

(*k*) **BLUSH TEST NUMBER** — The blush test is somewhat similar to the method of measuring the solvent power by toluol dilution. This test consists of diluting the solvent under test with blush inducing materials until the first faint blush occurs under standardized conditions.

The humidity chamber used in the test is maintained at 85°F and at 80% humidity. The solvent under test is used in preparing a solution of nitrocellulose, using 10 g. of dry  $\frac{1}{2}$  second nitrocellulose in a blend of 50 cc. of solvent under test and 50 cc. of toluol. A diluting solution is prepared using 10 g. of dry  $\frac{1}{2}$  second nitrocellulose in a blend of 50 cc. ethyl acetate and 50 cc. of benzol.

Dry glass panels are placed in position in the humidity chamber so that they may be flow-coated with lacquer through a small cylinder from outside the chamber. Measured blends of test solution and diluting solution are flow-coated on the glass panels and the ratio of the diluting solution to the test solution is taken as the blush test number. At this point, the blend should contain about the quantity of hydrocarbon low boiler and high boiler that appears in the average commercial type of lacquers. (See illustration No. 35.)

(*l*) **EVAPORATION RATE** — The rate of evaporation of liquids is an important function of any given lacquer in which it may be used. The evaporation rates of several high boiling solvents were determined in the following solvent mixtures with nitrocellulose:

|                                   |                      |
|-----------------------------------|----------------------|
| 4 sec. nitrocellulose (dry) ..... | 10 parts b.w.        |
| Toluol .....                      | 50 parts b.w.        |
| Butyl alcohol, normal .....       | 8 parts b.w.         |
| Butyl acetate, normal .....       | 26 parts b.w.        |
| High boiling solvent .....        | 16 parts b.w.        |
|                                   | <hr/> 110 parts b.w. |

Strips of sheet aluminum were dipped to an equal depth in the above nitrocellulose solutions and allowed to drain off. The time taken to dry was noted, and is as follows:

| <i>Solvent</i>          | <i>Time</i> |
|-------------------------|-------------|
| Ethyl lactate .....     | 27 minutes  |
| Ethyl oxybutyrate ..... | 20 minutes  |
| Cellosolve .....        | 17 minutes  |
| Butyl propionate .....  | 18 minutes  |

The evaporation rate of several lacquer solvents and diluents is also shown on the chart. (See illustration No. 36.)

(m) **HYDROLYSIS TEST**—One and one quarter per cent of water by weight was added to the following solvents; this being the maximum proportion of water which could be dissolved by butyl propionate.

Ten cubic centimeter portions of each sample was sealed in test

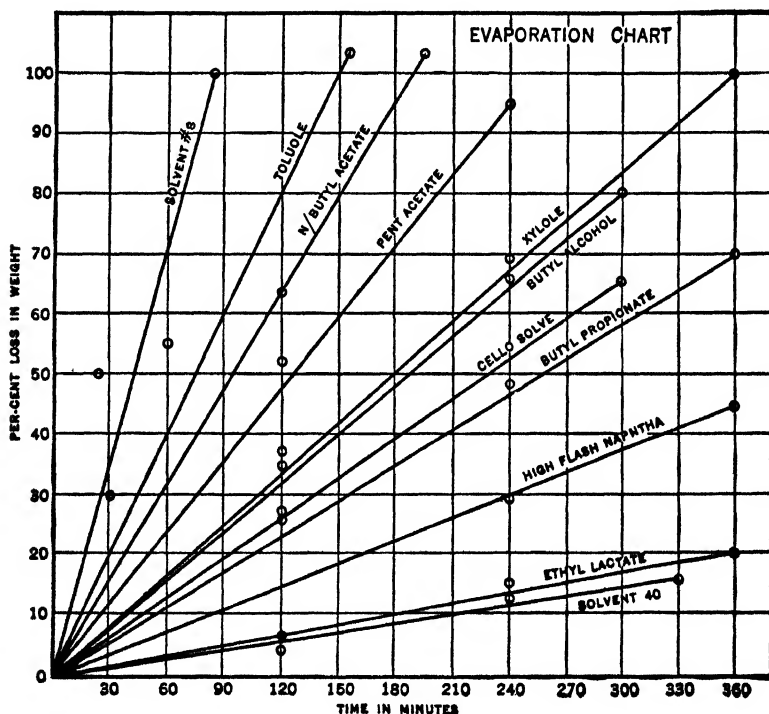


FIG. 36. Evaporation curves

tubes and immersed in a constant temperature water bath at 60°C for a period of 16 days.

The increase in acidity of each sample as determined by titration with  $n/50$  caustic potash was reported in milligrams KOH per gram sample (13).

| <i>Solvent</i>                   | <i>Mg. KOH</i> |
|----------------------------------|----------------|
| Fermentation ethyl lactate ..... | 6.73           |
| Synthetic ethyl lactate .....    | 2.48           |
| Ethyl acetate — 0.5% urea .....  | 1.12           |
| Ethyl acetate .....              | .36            |
| Butyl propionate .....           | .08            |

(n) **KAURI-BUTANOL TEST** — The Kauri-butanol test is a generally accepted and standard method of determining the solvent power of petroleum thinners.

The procedure is as follows: weigh 20 g. of the Kauri-butanol solution into a 200 cc. Erlenmeyer flask, and add the thinner to be tested from a 50 cc. burette (rapidly up to 25 cc., then slowly) until cloudiness appears. The number of cubic centimeters of thinner required is the kauri-butanol value.

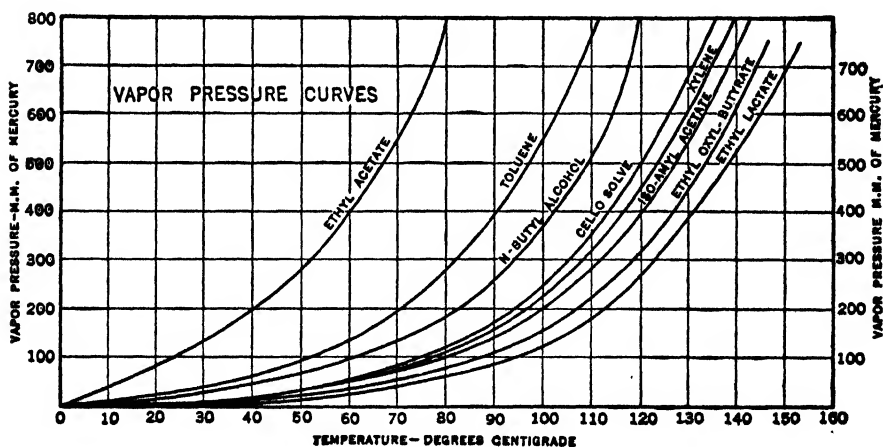


FIG. 37. Vapor pressure curves

(o) **VAPOR PRESSURE** — The vapor pressure of lacquer liquids is considered more important than their boiling ranges. Vapor pressure is the pressure measured in millimeters of mercury which, when brought to bear on a liquid, causes it to pass into the vapor state.

A chart (see illustration No. 37) shows the vapor pressure of several lacquer liquids.



## Thinners

(a) **METHOD OF MATCHING THINNERS**—To successfully match a lacquer thinner, the following analytical work on the submitted sample is necessary:

Specific gravity @ 15.5°C  
Sulphuric acid solubility  
Water solubility  
Distillation range

The acid soluble portion consists of alcohols, esters, and other solvents that are entirely soluble in  $\text{H}_2\text{SO}_4$ . The acid insoluble portion consists of coal tar or petroleum hydrocarbons. Usually the constituents of this portion can be easily identified by pouring the acid insoluble residue on water in a beaker and noting the odor.

When a match formula is prepared, it must be borne in mind that the acid and water solubilities must check the sample, and the distillation range must also be a reasonable duplication. The greatest amount of work toward duplication will be done by means of distillation. The liquid (solvent) specifications, and the boiling range of these various liquids are available and may be plotted. If the distillation is carefully studied and also the materials which are likely to be present, as manifested by analysis, the thinners are generally easily matched.

At present new lacquer solvents and materials are being presented to the industry almost daily. Beside coal tar diluents, many hydrocarbons are now used to substitute for toluol, wholly or in part. New nitrocellulose solvents are being introduced which, in addition to the chain esters, are soluble in  $\text{H}_2\text{SO}_4$ . It is, therefore, becoming more and more difficult to correctly duplicate a lacquer thinner or reducer (14).

(b) **BENZOL OR TOLUOL DILUTION FACTOR**—Dissolve a pinch of dry nitrocellulose in 10 cc. of the thinner. Add C.P. benzol or toluol in small amounts with vigorous shaking until the nitrocellulose is precipitated. The precipitation is best recognized by the appearance of the walls of the tube above the liquid, or by the manner in which the bubbles rise to the surface after shaking. The point at which precipitation is eminent is indicated by the solution becoming

fluorescent. The result is expressed in per cent of benzol or toluol required to produce precipitation.

(c) **HYDROCARBON TEST**—Place 200 cc. of special denatured alcohol No. 1 in a 500 cc. flask with 500 g. KOH and warm gently under a reflux condenser to dissolve as much of the caustic as possible. *Extinguish the flame* and add 100 cc. of the thinner cautiously, through the condenser. Boil gently under the reflux for 2 hours, then cool and add to 500 cc. of  $H_2O$  in a 1000 cc. distilling flask. Distill into a 500 cc. separatory funnel, *stopping the distillation as soon as all the hydrocarbons have passed over*. This can be determined by the disappearance of the oily layer in the flask and by the color of the distillate. The distillate in the separatory funnel contains all the hydrocarbons from the thinner, with some water and butanol and a considerable amount of alcohol. Add enough  $H_2O$  to bring the volume up to 400 cc., shake well, and allow to settle. Empty the residue from the distilling flask and drain off into it the watery layer (after settling) from the separatory funnel. Wash the oily layer with a second portion of 300 cc. of  $H_2O$  and add the washings to the distilling flask. Drain the washed hydrocarbons off into a 100 cc. cylinder. Dilute the washings in the distilling flask to a volume of 800 cc. and distill exactly as before, washing the distillate twice and adding the washed hydrocarbons to the first portion of the cylinder. Note the volume and take it as the per cent by volume of hydrocarbons in the thinner. Dry the hydrocarbons with anhydrous calcium chloride or magnesium sulphate and take their specific gravity by any convenient method. Transfer them to the 125 cc. distilling flask and distill as described under distillation.

(d) **TEST FOR ESTER**—Pipette 100 cc.  $n/10$  alcoholic carbonate free KOH into a 500 cc. Erlenmeyer flask and add 20 cc. of thinner to it from an accurate pipette. Boil slowly under a reflux for 2 hours, then cool and titrate with  $n H_2SO_4$  solution, using methyl red or phenolphthalein as the indicator.

(e) **FLOW-OUT TEST**—Place exactly 10 cc. of standard lacquer (especially prepared for testing thinners) in a 25 cc. cylinder and 15 cc. of the thinner that is being tested. Shake well and allow the bubbles to rise to the surface and break. Pour out the thinned (reduced) lacquer on a glass plate ( $2'' \times 4''$ ) and quickly set it in a

vertical position, in a place free from drafts and allow it to drain. The smoothness of the flow-out is best observed by looking through the glass (and the lacquer film on it) at a printed page.

(f) **BLUSH TEST** — Dissolve dry nitrocellulose in the thinner to give a solution of 10 second viscosity in a No. 4 Ford cup at 80°F and flow out on a piece of glass plate. Determine the humidity with a psychrometer and note whether a blush results. If not, increase the humidity in the room by spraying water with a spray gun and repeat tests until blushing results.

(g) **SULPHUR TEST** — Sulphur is to be determined on all thinners. The copper strip method is usually employed as follows: when running distillation, introduce a bright clean copper strip about  $\frac{1}{4}'' \times 2\frac{1}{2}''$  in the Engler flask. As the distillation proceeds, note discoloration, if any, and the point at which the shiny copper is completely hidden by the deposition of  $\text{CuSO}_4$ . This is an empirical test and one in which the personal equation plays a part. When a doubtful lacquer thinner is to be examined, the following method is used: 100 g. of thinner is shaken thoroughly in a separatory funnel with 25 cc. of 10% NaOH solution, liquids allowed to settle and lower layer drawn off into a beaker. The water layer is diluted to 400 cc. and about 20 cc. bromine water is added. The mixture is acidulated with HCl, the excess bromine is boiled off, and  $\text{H}_2\text{SO}_4$  in solution precipitated in the usual manner with barium chloride and calculated to sulphur.

(h) **SPECIFIC GRAVITY** — See test under solvents.

(i) **WATER SOLUBILITY** — See test under solvents.

(j) **DISTILLATION** — See test under solvents.

## Oils

(a) **ACID NUMBER** — Weigh 10 g. (.001) of oil in a 200 cc. Erlenmeyer flask; add about 50 cc. of neutral benzol-alcohol (2-1) mixture and connect with a reflux condenser and heat on the steam bath for one half hour. Remove from the bath, cool, add phenolphthalein, and titrate the free acid with  $n/5$  alcoholic KOH. Calculate acid number (milligrams KOH 1 g. oil) as follows:

$$\text{Acid number} = \frac{\text{cubic centimeters} \times \text{normality} \times 56.1}{\text{weight of sample}}$$

(b) **SAPONIFICATION NUMBER** — Weigh from 2 to 3 g. (.0005) of oil into a 200 cc. Erlenmeyer flask, add 50 cc. of  $n/2$  alcoholic KOH solution from a burette, connect with a reflux condenser, and heat on the steam bath for one hour. Cool and titrate with  $n/2$  HCl using phenolphthalein as an indicator. Run 2 blanks with 50 cc. of  $n/2$  alcoholic KOH at the same time. Calculate the saponification number (milligrams of KOH — gram of oil) as follows:

$$\text{Saponification No.} = \frac{(\text{blank titer-sapon titer}) \times \text{normality} \times 56.1}{\text{weight of sample}}$$

### Resins

(a) **CHILL TEST — ESTER GUM** — Fifty grams of gum are dissolved in 50 g. of ethyl acetate and held at a temperature of 0°F for 48 hours. At the end of this time there should be no crystallization. It is better to pulverize the gum before weighing, as it readily dissolves in this condition. The weights used for this test just fill a 4 ounce bottle.

(b) **MELTING POINT** — “ Since resins have no true melting point in the physio-chemical sense, and since the fluidity of resins increases with temperature while the physical hardness decreases, we believe that the best way of determining this physical characteristic of resins is to subject them at an arbitrary and constant temperature to an arbitrary and constant pressure — thus calling *flow point* of a resin the *time temperature* reading on a gum plug of definite *dimensions* at which the constant weight *applied* perforates the gum plug ” (15).

### Method

A constant heat supply is provided by a jacketed glass vessel, the inner space being heated by the vapor of a liquid kept at the boiling point in the jacket. By a proper choice of liquid, a great variety of temperatures can be obtained. It is advisable to have several of these apparatus, each adjusted for a desired temperature.

The inner space, covered by an asbestos plate which carries the thermometer and the test tubes, provides the hot zone for the “ flowing point ” test.

The test must be made with six tubes, which allow the testing of three gums simultaneously, two plugs of each being tested for check.

If less than three gums are tested, more can be taken for check or "dummies" carrying mercury only.

### Making the Gum Plugs

The six test tubes, open on both ends, are 100 mm. in length, with an inside diameter of 8 mm., wall thickness of 1 mm. Place a mark 9 mm. from one end of each of the glass tubes; place a cork in the other end and fill with mercury to the 9 mm. line. The rest of the tube (the 9 mm.) is now filled with resin, melted in a small porcelain dish at a temperature sufficient to make the resin quite liquid. Pour an excess of molten resin on top of mercury so that the tube overflows with gum free from air bubbles. Allow the tubes to cool and then clean off excess gum so that each tube has a solid plug of gum 9 mm. in height and even with the bottom of the tubes. The corks may now be removed and the mercury poured out. Reverse the tubes and add to each, on top of the plugs, 4 cc. of mercury from a burette. The tubes are now introduced through the openings in the asbestos cover so that about  $\frac{1}{4}$  inch — same for each tube — extends above the top of the asbestos. This is done by means of small rubber bands on the tubes to hold them in place. The tubes are all bunched together and the thermometer in the center indicates practically the temperature of the tubes themselves.

### Procedure

While the plugs are being made, the apparatus is brought to constant temperature by heating the bottom with a small gas flame, sufficient to keep the liquid boiling and the vapors reaching the first bulb of the condenser. When the tubes (which are of room temperature) are introduced, there is a drop in temperature in the inner space, which very soon begins to rise again slowly, taking about half an hour to reach the original constant temperature. The time is counted from the moment of introduction of the tubes. As each plug gives way and the mercury breaks through, the time and temperature are noted. The result is reported in both time and temperature. Under normal conditions these are correlated, but slight variations occur depending on room temperature.

## Remarks

Care must be taken to obtain plugs of good mechanical quality. Reject all that crack badly on cooling or show defects, and use only clean mercury and clean tubes in preparing the plugs. With high melting gums, it is advisable to reduce somewhat the lower end to prevent the slipping out of the whole plug.

For "Paranol Hard," the temperature of the inner space should be 115°C. This is obtained by using technical butyl acetate as the liquid in the jacket.

"Paranol Extra Hard" is tested at 125°C, the liquid for this temperature is a mixture of 90 parts xylol and 15 parts of butyl acetate. Adjustments can be made (even during the test), if necessary, by adding small amounts of liquids through the condenser.

(c) DETERMINING THE ACID NUMBER — Dissolve 5.6 g. of gum in pure benzol or a mixture of benzol and alcohol (make certain the benzol is neutral). Titrate with  $n$ -1/10 alcoholic solution of KOH and the number of cubic centimeters of KOH solution necessary to neutralize this solution of benzol and gum represents the acid number of the gum.

The author directs attention to a paper "Some Methods for the Detection and Identification of Synthetic Resins," by Theodore F. Bradley, for analytical investigation of synthetic resins (16).

## Lacquers

### QUALITATIVE TEST FOR NITROCELLULOSE SOLUTIONS

(a) DIPHENYLAMINE TEST — Nitrocellulose can be detected in a lacquer qualitatively by means of diphenylamine dissolved in concentrated  $H_2SO_4$ . The solution is approximately 5% diphenylamine and 95%  $H_2SO_4$  of 1.84 sp. gr. This test can be applied to dried lacquer films or to a wet sample of the lacquer.

If a dry film is to be tested, several drops of solutions are put on the film and rubbed around with a glass rod. If nitrocellulose is present an intense dark blue color will develop almost instantly. If a wet sample is to be tested, put a small amount on a watch glass and evaporate the thinners and then make the test as on a dried film.

(b) **ROSIN TEST** — *Liebermann-Storch Method* — Dissolve the material in acetic anhydride, using heat if necessary, place a few drops of the solution on a porcelain crucible cover. Add 1 or 2 drops of  $\text{H}_2\text{SO}_4$  (34.7 cc. conc.  $\text{H}_2\text{SO}_4$  and 35.7 cc.  $\text{H}_2\text{O}$ ) from a dropping bottle so that it will mix slowly. If rosin is present, a characteristic violet fugitive color will result.

*Halpen Method* — The Halpen reagent consists of two solutions: (1) one part by volume of phenolphthalein dissolved in 2 parts of  $\text{CCl}_4$  and (2) one part by volume of bromine in 4 parts of  $\text{CCl}_4$ .

The procedure which is found most convenient for conducting the test is as follows: A small quantity of the powdered rosin, or the residue resulting from the evaporation of the ethereal extract of a larger quantity of the substance to be investigated, is dissolved in 1 to 2 cc. of solution (1). This solution is poured into one of the cavities of an ordinary porcelain color reaction plate until it just fills the depression; a portion of the solution will soon spread out on the flat part of the plate a short distance beyond the rim of the cavity unless too much of the  $\text{CCl}_4$  has been lost through evaporation during the process of solution, when a drop or two more should be added to produce the spreading effect above referred to. Then immediately in an adjacent cavity of the plate is placed a cubic centimeter or so of solution (2), and the bromine vapors evolved are followed to impinge upon the surface of the solution of the other cavity. Sometimes it is necessary to blow a gentle current of air in the proper direction to accomplish this satisfactorily, or both cavities may be covered by a watch crystal of suitable size.

The color reaction begins almost immediately with the contact of the bromine vapors and are best observed upon the flat portion of the test plate. In most cases they last long enough for satisfactory observation; the changes in color are practically over, however, in a period varying from 5 to 10 minutes. This method has been found very satisfactory where rosin was the only adulterant; where the rosin is in admixture with other gums, as may be the case, this method has not proven satisfactory (Holley).

(c) **TOTAL SOLIDS IN LACQUERS** — This determination is always made in duplicate. The weight of the sample used is always by difference by taking the lacquer from a dropping bottle with a ground-in

pipette and a rubber bulb on the end of the pipette. A dropping bottle of 30–40 cc. capacity is the most convenient size. A sample should never be taken by direct weight as the volatile portion of the sample will evaporate so quickly that accurate weighing is impossible.

The solids are ascertained by determining the loss in weight of a sample which is placed on a weighed pan. The pans used are ordinary paint can covers of  $3\frac{1}{2}$  inch inside diameter and  $\frac{5}{16}$  inch depth. Sea sand is sprinkled on the bottom of the pan and spread out to cover the entire area. The only sea sand which can be used accurately is that which has been prepared and will not lose weight on heating. This grade of sand is called "Ottawa sea sand" and can be obtained from any chemical supply house. If this sand is kept in the oven before use, it will always be dry. The sand should be placed on the pan, and the pan and the sand weighed as soon as the sand is cool. Record the weight accurately to the fourth decimal place as shown by an accurate chemical balance.

The weighing bottle containing the lacquer is now weighed and the sample is squirted over the sand, sufficient sample being used to cover every sand particle. This will vary from  $2\frac{1}{2}$  to 3 g. The bottle is again weighed and the difference in weight is the weight of the sample. The can lid plus the sample is now placed in an oven of the Fries type with a ventilating outlet for the solvents to escape as they are evaporated and are heated for three hours at  $105^{\circ}\text{C}$ . At the end of three hours the pan is removed, placed in a dessicator to cool, and weighed. The loss in weight of the sample is found by difference in weight between the second and the first weighing. Calculate as follows:

$$\frac{(\text{second pan weighing}) - (\text{first pan weighing})}{\text{weight of the sample}} \times 100 = \% \text{ solids}$$

It is important that none of the sand is lost between the first and second weighings and that all the sand is covered with the lacquer sample, otherwise some sand may be lost in handling with the consequent error in results. The sand is used to give a greater surface and prevent trapping of volatile matter. Care must be taken not to use a temperature in excess of  $105^{\circ}\text{C}$  and the heating period should be exactly three hours. Results on two determinations should check within .5%. If they do not, the work should be repeated.



(d) **TOTAL SOLIDS IN LACQUER BASES** — In determining the total solids of lacquer bases, pans of the same sizes are used, but no sand. Bases are too heavy in body to be weighed from a dropping bottle, and the sample is taken directly from the sample can. Each pan is supplied with a cover while the sample is being weighed. The cover can be an ordinary pan and the same cover can be used for all determinations.

The determination is made as follows: The pan plus cover is weighed. Some of the lacquer base is then smeared on the bottom of the pan with a small spatula, the cover replaced on the pan and again quickly weighed. This second weighing records the weight of the sample taken. The cover is then removed and the pan is placed in the oven for three hours at 105°C. It is removed, cooled, and weighed. This third weighing is also made with the cover.

The second weighing, by which the weight of the sample is obtained, must be made very rapidly, as some solvent is lost even though the pan is covered. Therefore, rapid weighing is necessary to keep the loss to a minimum. When the sample is smeared on the pan it should be smeared in a thin layer as the thicker the layer the greater the possibility of trapping solvents and obtaining high results.

(e) **TOLUOL PRECIPITATION METHOD FOR LACQUERS** — This method is used in the quantitative analysis of nitrocellulose lacquers when it is desired to know the percentage of nitrocellulose, oil and resin. The method is accurate within reason, rapid, and gives good results with lacquers in which shellac is one of the gum constituents. This method is not as involved as the extraction by ether method, and the result can be excellent if care in technique is observed.

## Method

The total solids of the lacquer are determined in the usual manner. Still using the lacquer sample left in the dropping bottle, a sample of 1.5 to 2.0 g. is put into 100–150 cc. toluol in a 250 cc. beaker. Duplicates are always run. The sample is stirred well in the toluol, and the beaker is covered and allowed to stand for about two hours. (The standing is not absolutely necessary if the precipitate is kept in agitation for a short time.)

Prepare Gooch crucibles on which to filter the precipitated nitro-

cellulose. These are made up with the ordinary prepared asbestos and care must be exercised not to make the mat too thick, otherwise difficulty will be experienced in filtering. The crucibles are dried in the oven at  $105^{\circ}\text{C}$  to constant weight. After weighing the crucible, the precipitate in toluol is filtered off. The precipitate is all the nitrocellulose and possibly some of the resin. The filtering is done, of course, with suction and the precipitate is washed well with toluol.

The best and most effective way to do the washing is by percolation. The crucibles are taken off the suction flask and suspended over a 5 inch crystallizing dish in some suitable manner, the crucible is filled with toluol and permitted to filter through as fast as it will until nearly dry and it is then freed of the last toluol by suction. The toluol washings are evaporated on an electric hot plate to get the resin and the oil content.

After the toluol treatment, the precipitate in the Gooch crucible is given the same treatment of filtration and percolation with butyl alcohol. The butyl alcohol used should be redistilled to purify it. Care should be taken that the butanol be allowed to percolate slowly so that it is in contact with the precipitate. Only in this way is it possible to wash out the last traces of resin. The crucibles are then dried at  $105^{\circ}\text{C}$  to constant weight, cooled and weighed. The precipitate weighed is only nitrocellulose. The butanol washings are also evaporated to get the resins and oils which it dissolves.

In the case of pigmented lacquers, the same procedure is followed, except the final precipitate weighed will be nitrocellulose and pigment. In order to determine the correct amount of pigment, it is necessary to centrifuge the lacquer with a mixture of  $\frac{1}{3}$  each of benzol, acetone and ethyl acetate.

If high viscosity nitrocellulose is used in the lacquer, the precipitate in toluol is boiled for 5–10 minutes. This will free traces of resin and oil that might be held by the nitrocellulose.

(f) **WEIGHT PER GALLON** — The American Society for Testing Materials specifications are applicable. Here it is indicated that at least one pint of the material under test is accurately measured and weighed at a temperature of  $20^{\circ}\text{C}$ . The result is expressed as pounds per gallon.

The Krebs Pigment Company use a transparent cylinder with

cover, which is employed to determine the weight per gallon. This container will hold 83.3 cc. of water, which, at a specific gravity of 1.000 indicates the true weight of water as 8.33 pounds per gallon. In like manner, the weight of the filled container will indicate the weight per gallon of the particular material (less, of course, the weight of the container).

### **Clear and Flat Lacquers — Bronzing Solutions**

(a) **VISCOSITY** — Use standard methods — see **VISCOSITY**, this chapter.

(b) **RESIDUALS** — Dry a 2 or 3 g. sample to constant weight at 100°C. In making this test valuable information can often be obtained by noting the odor as the evaporation progresses, as to the solvents, resins, and plasticisers used.

(c) **FLOW-OUT AND CHARACTER OF FILM** — Flow out the lacquer on a piece of glass and allow it to dry. Note the drying time and examine as directed under “flow-out test, thinners.” If a comparison is to be made with another lacquer, the viscosity must be adjusted to the same point. Even so, the result will be influenced by the thinner used. Set the strip aside for several days and note the character of the film after 24 hours and after a week or two. Note the gloss or degree of flatness, hardness, toughness, or brittleness.

(d) **BENZOL OR TOLUOL DILUTION FACTOR** — As directed under thinners.

(e) **EXTRACTION** — Thin the lacquer to about spraying consistency, if the viscosity is above that point, and determine the residuals at this viscosity. Place 10 cc. in a stoppered weighing bottle and weigh. Pour slowly and with vigorous stirring into about 150 cc. benzol, toluol, or petroleum hydrocarbon, so that the nitrocellulose is precipitated in a fluffy form. Obtain by difference the weight of the sample so treated. It is often necessary to experiment with different amounts of thinner and different mixtures of benzol, toluol, or petroleum hydrocarbon to find the procedure which gives the best precipitate with the particular lacquer.

When a good precipitate has been obtained, transfer it to a Gooch crucible and extract it in a Wiley extractor with benzol. Dry and weigh the residue when all benzol soluble substances have been removed. The residue may contain, in addition to nitrocellulose, any

resins such as shellac which are insoluble in benzol. Whether this is the case can usually be judged by the appearance, but if there is any doubt, it can be removed by burning a small fragment.

A clear sodium flame indicates complete extraction while a luminous smoky flame shows that the residue still contains resin. If it does, the extraction should be continued with a 50–50 mixture of S.D. No. 1 alcohol and petroleum hydrocarbon. This frequently gives a fair separation of alcohol soluble resins from the nitrocellulose, but more often the result is not satisfactory. The separation of alcohol soluble gums from nitrocellulose is very difficult. Cold alcohol sometimes works well.

The nitrocellulose at any rate is dried and weighed after it has been extracted as well as possible and calculated as per cent of the total residuals.

The benzol extract is added to the hydrocarbon used for precipitating the lacquer and evaporated to dryness. This extract contains the hydrocarbon soluble resins, the plasticiser and any wax or metal stearate that may be present. The consistency and odor of the residue after evaporation are noted.

The alcohol extract is also evaporated and its nature observed. From this extraction, the nitrocellulose content of the lacquer can usually be determined fairly accurately and a rough idea can be gained of the amount of the plasticiser and the amount and nature of resins can roughly be estimated.

(f) **LIEBERMANN-STORCH TEST** — A few drops of the lacquer or a small bit of the evaporated benzol extract are boiled with 2 cc. acetic anhydride and cooled. About 1 cc. of this is then poured out into an evaporating dish and treated with a drop or two of 50%  $\text{H}_2\text{SO}_4$ . The color which develops frequently indicates the resin present; particularly ester gum, and it also gives a characteristic color with blown castor oil. (See test under **QUALITATIVE TEST FOR NITROCELLULOSE SOLUTIONS — ROSIN TEST**, this chapter.)

(g) **EXAMINATION OF SOLVENT** — It is not usually necessary to separate and examine the solvent from a lacquer, but sometimes it is found necessary. The following procedure may be followed:

Place 200 cc. of the lacquer in a 1000 cc. distilling flask and add 300 cc. dibutyl phthalate. Connect with a condenser and distill until

the temperature of the liquid in the flask rises to 110°C. When this point is reached, stop distillation and cool the content of the flask. Add 300 cc. of water and resume the distillation, collecting this distillate separately from the first. Continue distillation until the boiling point rises to 100°C, separate this oily layer from the aqueous layer of distillate, and distill each separately. The oily layers may contain hydrocarbons, esters, some alcohols and some water, while the aqueous layer will contain much water and the greater portion of any alcohol the lacquer may contain. The object in the distillation of either layer is the elimination of water, and distillation should be made in such a manner as to accomplish this as completely as possible and with as little loss of other materials. Several distillations may be required. When the water has been practically eliminated from both portions of the distillate, they are combined with the part which comes over before the addition of water, and the mixture of solvents so obtained is treated as directed under thinners.

This procedure has the weakness of introducing water into the solvent which can be removed only with considerable difficulty. Furthermore, it does not detect cellosolve, ethyl lactate, or other solvents which are readily soluble in water and have relatively high boiling points. When these are present, another procedure must be followed; this consists of precipitating the lacquer in kerosene which has been steam distilled to remove the low boiling portions, removing the nitrocellulose and distilling the liquid without the introduction of the water.

The kerosene has a boiling point high enough to permit it to be fractionated readily and sharply from most of the lacquer solvents. The results of either of these methods of determining the solvent composition of lacquers are only approximate and there is much room for improvement.

### Tests for Cellulose Acetate

The following analytical tests are included as an aid to those interested in the practical application of cellulose acetate. No criteria are given and in the development of cellulose acetate for a particular purpose, the technical departments of the large manufacturers offer ready assistance.

(a) **MOISTURE** — Approximately 2.000 g. of cellulose acetate are carefully weighed in a tared, glass stoppered weighing bottle which is about 8 cm. high and 4 cm. in diameter. The bottle with its contents is dried, with the cover off, overnight in a 105–110°C electric oven. The bottle is then stoppered and placed in a desiccator and allowed to cool to room temperature. It is weighed and the loss in weight taken as the amount of moisture in the sample.

$$\% \text{ moisture} = \frac{\text{loss in weight}}{\text{weight of sample}} \times 100$$

(b) **ACETYL CONTENT** — The material to be analyzed is dried to constant weight at 100°C and a sample (0.5 g. for material containing about 25% or more of  $\text{CH}_3\text{C}:\text{O}$  and 1.00 g. for material of lower acetyl content), is accurately weighed and put into a 250 cc. Erlenmeyer flask. To this are added 20 cc. of 75% ethyl alcohol and the flask is kept at 50–60°C for one half hour. To the flask are then added 20 cc. of *n* 2 sodium hydroxide; the flask is tightly closed with a rubber stopper, kept at 50–55°C for one quarter hour and then at room temperature, with occasional shaking, for forty-eight hours. At the end of this time, the sides of the flask are washed down with 50–75 cc. of distilled water, 2 drops of 1% phenolphthalein solution are added, and the excess alkali is back titrated. With some samples there is a tendency for the cellulose to retain some of the alkali after the solution becomes colorless. In such cases it is necessary again to stopper the flask and to allow it to stand, adding standard acid from time to time until the solution shows no further tendency to become red (17).

$$\% \text{ CH}_3\text{C}:\text{O} = \frac{.0215 \times \text{no. of cc. of } n2\text{NaOH}}{\text{weight of the sample}} \times 100$$

(c) **VISCOSITY** — To 90 g. of dry cellulose acetate in a 32 ounce bottle are added 360 g. of pure dry acetone. The bottle is closed with a tightly fitting glass stopper and tumbled end over end for twelve hours in a mechanical tumbling machine.

After the cellulose acetate is thoroughly dissolved, the solution is brought to a temperature of about 25°C, and is poured into a glass cylinder, 14 inches high and of an inside diameter of 1½ inches from the top, and the lower 2 inches from the bottom of the cylinder. The

cylinder is placed in a water bath maintained at 20°C, until the temperature of the cellulose acetate solution has become constant and uniform, and any bubbles have risen to the surface. It is then placed in such a position that a ball falling through the solution would be visible throughout its passage down the column. A standard steel  $\frac{1}{16}$  inch ball bearing (diameter .792-.797 cm.) weighing between 2.033 g. and 2.035 g. is then placed on the center of the top surface of the solution in the cylinder and allowed to fall through the solution. The time in seconds required for the steel ball to pass through the 10 inch column of the solution between the two graduations, as measured by the stop watch, is taken as the viscosity.

(d) DILUTION RATIOS WITH CELLULOSE ACETATE — Ethyl lactate and methyl oxybutyrate are excellent solvents for cellulose acetate. The dilution ratios of several cellulose acetate solutions were determined with benzol as the diluent.

Two gram portions of cellulose acetate were dissolved in 20 cc. of the solvent and diluted with benzol until precipitation occurred. The volume of diluent divided by the volume of solvent originally used (20 cc.) represents the dilution ratio:

| <i>Solvent</i>           | <i>Benzol<br/>(Diluent)</i> |
|--------------------------|-----------------------------|
| Acetone .....            | 0.90                        |
| Ethyl acetate .....      | 0.25                        |
| Ethyl methyl ketone..... | 0.20                        |
| Diacetone alcohol .....  | 0.95                        |
| Ethyl lactate .....      | 2.40                        |
| Ethyl oxybutyrate .....  | 0.90                        |
| Methyl oxybutyrate ..... | 1.30                        |

#### PHYSICAL INVESTIGATIONS APPLICABLE TO LACQUERS AND ALLIED PRODUCTS

##### Abrasion Test

The object of an abrasion test on lacquer, synthetic enamel and similar coating films is to determine its resistance to wearing. Such substances used for "wearing away a surface by friction" are: pumice stone, rotten stone, charcoal, sand, sandpaper, and steel wool. Lacquers, especially when applied on metal surfaces (motor car surfaces),

are subjected to the action of sand, dirt, etc., which has a weakening action on the film.

An abrasion meter is used to determine such resistance. The laboratory test involves a closed apparatus. (See illustration No. 38.) Lacquer films for testing purposes are prepared on glass plates by a

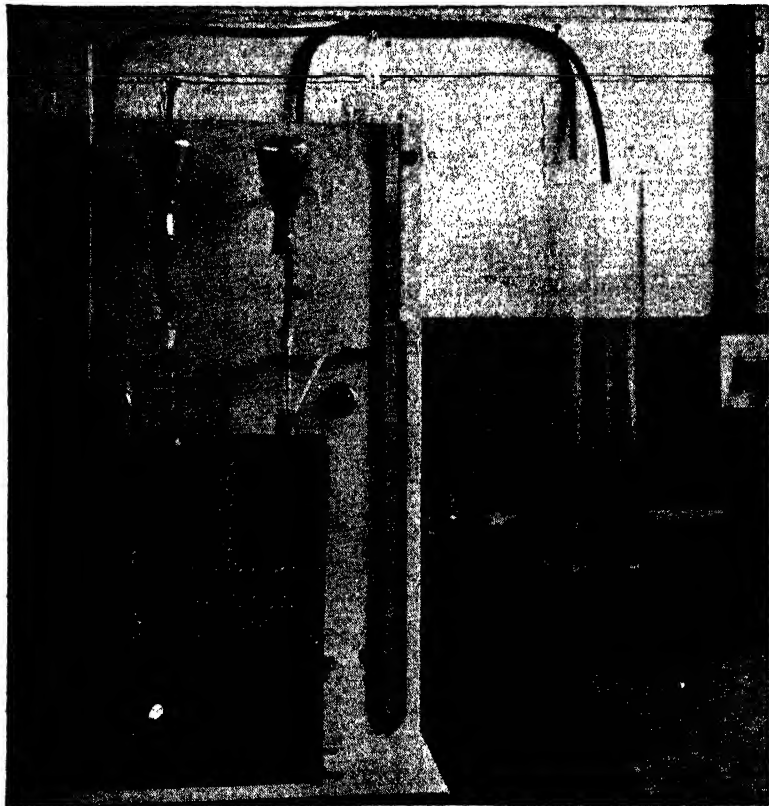


FIG. 38. Abrasion meter

spinning device, which will insure an even film thickness over the entire surface. The film thickness is calibrated with a micrometer and the film should be thoroughly dried before running the abrasion test. It has been advocated by some investigators that the film should age for at least two weeks at room temperature, although a reasonable time would involve whatever time is necessary to insure entire evapo-



ration of volatile solvents. After drying, the glass plate is fitted in the closed cabinet at an inclination of 45 degrees. The abrasive is placed in an inverted container at the top of the cabinet and is released; dropping through a standard orifice by gravity in a fine stream, where it comes in contact with a blast of air. This blast directs the abrasive agent against the glass panel (which is stationary). The air and its flow against the panel is a very important part of the test and the air pressure is closely controlled. A shielded light bulb is placed in back of the panel so that the film failure may be followed, and as the film is worn through to the glass surface, the flow of abrasive is ceased. The rupture is easily discerned and appears as ruptures in the finish (through the film).

The abrasive is weighed before testing and after rupture has been definitely established. The difference is the abrasive factor.

A machine termed "Finish testing machine" (sand wear type) is used to good advantage, and is similar to the device as used by the Bell Telephone Laboratories.

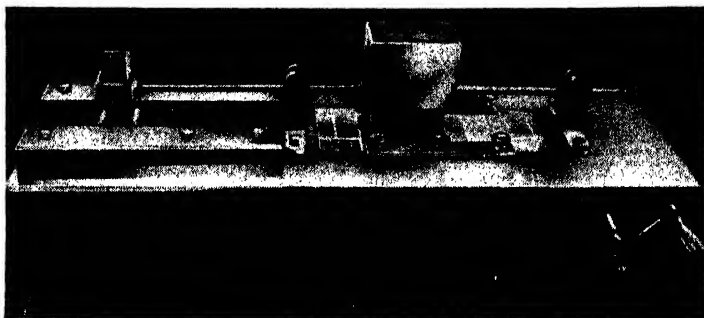
The lacquer under test is applied to sample discs. The discs are attached to the end of a vertical shaft which is rotated by a motor. The speed is regulated and the disc, coated with lacquer or synthetic enamel, is rotated inside a vessel which is filled with sand to a level of about 5 inches above the top surface of the disc. Rotation of the disc in sand wears off the finish. Compressed air keeps the sand in continuous circulation and this prevents an undue accumulation of heat which might soften the finish. Dust particles are drawn into a vacuum container.

Test specimens 4 inches in diameter are used and the surface is flat and parallel. The center hole is concentric with the periphery and close fitting on the projecting end of the spindle. 20-30 size Ottawa sand is used as the abrasive and the thickness of the film is controlled by micrometer readings which are taken before the test and after. The wearing quality is expressed by a numerical scale, (this is expressed in the loss of film material per 500-1000 revolutions, etc.), based on the number of thousands of revolutions required to bring the wear line to the circle halfway between the center and the outer periphery of the disc.

### Abrasion — Toughness

Finishing materials applied on numerous objects are subjected to frictional contact and marring.

A machine device used in testing lacquer and synthetic enamel finishes is termed an Abrasion Tester. This machine, in the form of a lathe block, is operated by a motor attachment. The lacquer or similar coating material to be tested is applied on a metal panel and after proper drying (air-drying or baking), the panel is firmly secured in a space provided. A weighted block is secured to a horizontal driving shaft, which passes back and forth over the area of the coated panel. Sandpaper of proper grit fineness (or similar abrasive) may



*DuPont Co.*

FIG. 39. Abrasion-toughness test

be attached to the weighted block, and a counter indicator records the passage of the block over the surface. Test is conducted using a standard of known resistance and test is continued until the film has been worn through to the bare metal. (See illustration No. 39.)

Another form of abrasion machine is used in the testing of metal lacquer or synthetic enamel finishes. In this test, a solid rubber piece (as an abrasive) is passed over the coating film. This “rubbing” action resistance is the value sought and the number of strokes required to rub through the finish is an indication of its wear resistance.

### Adhesion — Flexibility

One of the very important assets of a lacquer or similar finishing material is its adherence to the surface on which it may be applied.

Another, equally as important, is its flexibility retention after aging and while in use. (Adhesion is the act or state of anchoring or adhering to a surface, while flexibility is the act of retaining elasticity. Without the latter, coatings would not exhibit true adhesion, especially to metal surfaces.)

Practically every coating finish is subjected to abuse of some sort and if the use of the coating is known its resistance to handling may be predetermined.

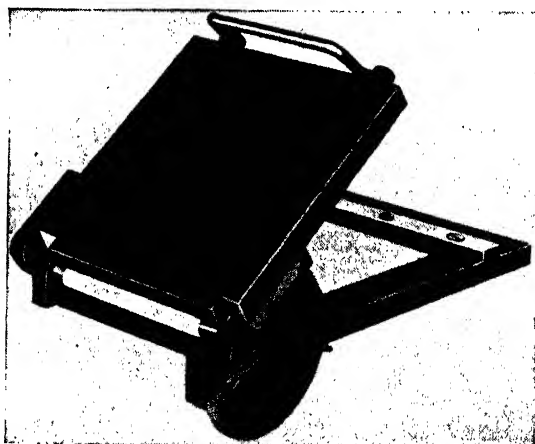


FIG. 40. Bend test

It is unfortunate that no standard method of determining adhesion values now exist. The tentative specifications proposed by Subcommittee XXV of Committee D-1 of the American Society for Testing Materials has been used by some investigators as a basis for determining this value. Several large manufacturers and users of coatings, among them the Du Pont Company and Bell Telephone Laboratories, have their respective machine evaluations and it is the author's belief that such determinations are of a great value.

The "finger nail" test is still used and adhesion values are obtained by rule of the person with the stronger thumb nail. However, such comparative values are only of academic interest. This test is also used in determining "hardness" of an applied coating.

The "mandrel" or "bend test" is used by industry and is defined

as a relative value, from which is obtained both adhesion and flexibility determinations. Coatings are applied on metal panels of thicknesses up to 0.159 cm. ( $\frac{1}{16}$  inch in thickness) and of varying sizes, in accordance with the size of the "bend tester" or "mandrel." The coated panel, of a definite film thickness, is thoroughly dried and aged before testing and is clamped at one end so that the opposite (free) end may be bent about a mandrel of various radii ( $\frac{1}{8}$ " to 1"). The object is to determine the smallest radius which will rupture the film. In order to obviate the tedious process of testing too many panels, the Underwood-Elliott-Fisher Company Laboratories have devised a machine whereby a coated panel may be passed over different radii at the same time and yet preserve the panel for further testing.

The distensibility of the finish is expressed as the maximum per cent elongation which the finish will withstand without cracking or flaking, through a 180 degree arc in 15 seconds. (See BEND TESTER, illustration No. 40.)

When certain finishing materials are stretched to the cracking point, they loose themselves entirely from the surface on which they had been applied, others may exhibit slight adhesion but may be removed with ease, while still others are removed with difficulty or not at all.

A very severe adhesion test (which is also applicable to "hardness test" is the CRISS-CROSS TEST (See illustration No. 41). Where films of limited distensibility are used (certain lacquer films as an example), this test has little value and where air-drying lacquers are applied over baked oil primers, little is to be gained. It is, however, a very good test for wood lacquers and for synthetic enamel films.

An octagon shaped piece of brass plate about  $\frac{1}{16}$  inch in thickness and a diameter measurement of 3 inches is used. This plate rests on four pegs,  $\frac{1}{8}$  inch in height. These pegs are pointed so they may be impressed into the coating film, thereby gaining good anchorage. The face of the plate is slotted in 6 or 7 spaces that are 2 inches long and of a diameter thickness sufficient to permit a razor blade to pass through freely. The instrument is placed on the panel surface,

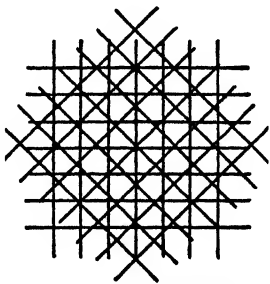
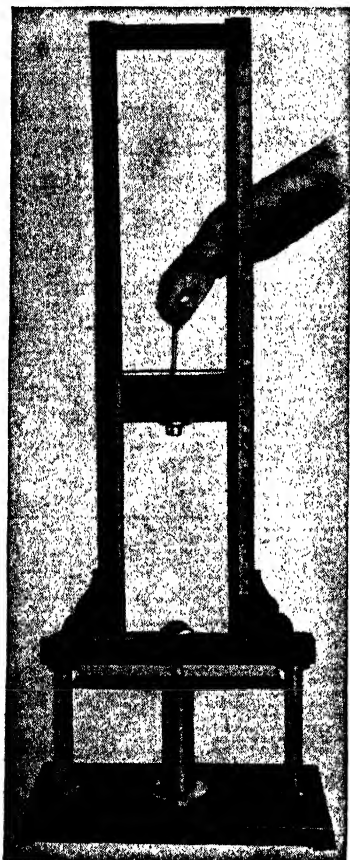


FIG. 41. Criss-cross test

pressed into the finish and a sharp razor blade is drawn the length of each slot, thus cutting or ribboning the film. The instrument is then turned clockwise to the next hole produced by the sharp peg and knife or blade is again drawn, producing ruptures or ribbons at a right angle to the first cutting. This is continued until four cross-lines are produced. Where each of the four  $\frac{1}{4}$  inch lines cross each other, a sharp point will result.

The value is one of comparative nature and is examined under the low power microscope, being compared with a coating of known performance.



*DuPont Co.*

FIG. 42. Impact test

### Impact Test

Coating materials are placed on a 20 gauge steel panel, dried and aged. The panel is then placed between an anvil and a movable steel ball. A movable weight is placed on the cross-arm which is dropped on the ball, causing it to dent the panel. Adhesion and flexibility are then measured by determining the relation between the weight dropped, the height of the fall and the extent of the damage (rupture of the film) by the impact of the ball on the plate. In determining this test value, a finish which is of known performance is always compared with the finish under test.

(See illustrations Nos. 42 and 43.)

In the HART IMPACT TESTER, developed by the Henry A. Gardner Laboratory, a specially designed hammer (530 g. in weight) is allowed to fall upon a coated steel panel, which is cushioned on sheet

rubber (see illustration No. 44) and the extent of the damage is determined in much the same manner as described above.

The Bell Telephone Laboratory Impact Test involves the subjecting of a steel coated panel to blows by a case-hardened steel ball on a short arm, which pivots on the end of a longer arm, rotating at a constantly increasing speed. The "Impact value" is taken as the revolutions per minute of the ball at the point where the finish is first removed from the panel.

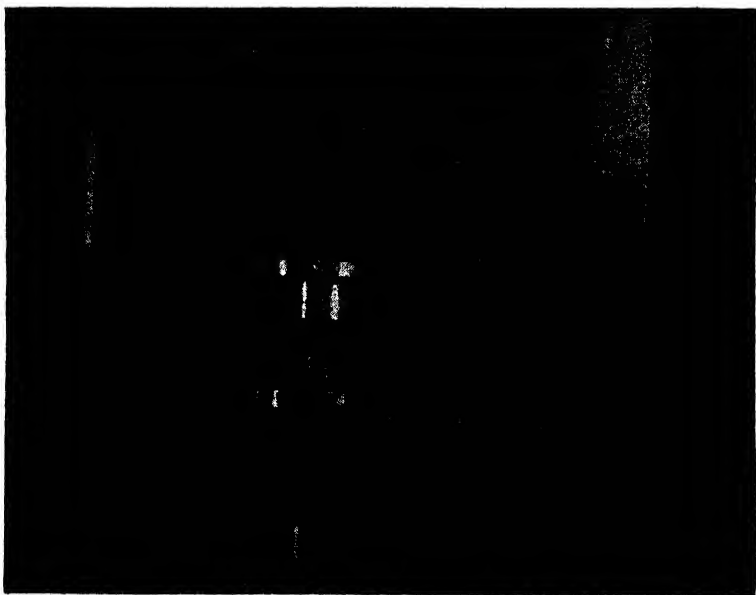


FIG. 43. Impact test

*DuPont Co.*

In the evaluation of coatings by percentage ratings, it is the opinion of this author that adhesion should carry a high value (at least 20%). In other words, if a finish were to withstand both mandrel and impact tests, without exhibiting a fracture as determined by a low power microscope examination, the value would be 20%.

### Alcohol Resistance Test

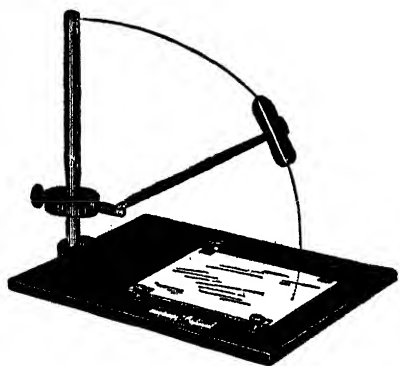
This test value is applicable to clear lacquers as applied to wood surfaces. Desks, tables, dressers, and similar furniture are subjected

to the spillage of perfume, which is chiefly alcohol, and to spillage of beverages, etc.

The test is made by pouring denatured alcohol on the finish, permitting the alcohol to evaporate and then examining the finish to determine whether any marks remain where the alcohol has been spilt; whether the finish has turned gray, or whether the gloss has been affected.

When conducting such tests, the regular alcohols should not be used. Such alcohols contain an active lacquer solvent as a denaturant which will affect the lacquer film in much the same manner as lacquer thinner. Alcohols used in lacquers are usually of the 180 proof variety and they should be diluted with water to 90 or 100 proof before testing the finish.

Occasionally an alcohol print test is run (see **PRINTING TEST**, this chapter) to duplicate the cap-  
tivation of alcohol as enacted when



*H. A. Gardner Labs.*

FIG. 44. Hart impact test

spilt down the sides of a glass and the alcohol is held by the base of the glass container.

Certain synthetic resins are considered alcohol resistant and are used in clear wood lacquer formulation. (See **SYNTHETIC RESINS**, Part I, Chapter V.)

## Baking Tests

Such products as oil, primers, or synthetic enamel finishes, which require heat treatment to evaluate their true worthiness, should be baked for a definite length of time and at a definite degree of heat. The time and temperature should be determined in the testing of such products. There are such faults of finishing materials as "under" and "over" baking. Synthetic enamels require a definite temperature to enact "curing" and certain light colors of synthetic enamels will not tolerate too high a temperature. These influences should be definitely established. (See illustration No. 45.)

Nitrocellulose finishes, being air-drying coatings, are not subjected to "baking," however, certain basic nitrocellulose finishes which have been "fortified" with a ratio of 6 to 10 parts of synthetic resins lend themselves to a heat treatment.

*Industrial Finishing***FIG. 45. Baking ovens**

### **Cold Check Test (Temperature Change Test)**

This test is described under "Furniture Finishing," Part IV, Chapter XII.

### **Color of Clear Lacquers and Synthetic Resin Varnishes**

The color of clear lacquer or varnish is determined by a set of eighteen standard glass tubes. Of these standards, the Henry A. Gardner Laboratory says, "It has been found that mixtures of inorganic salts, namely: ferric chloride and cobalt chloride, dissolved in weak HCl, may be satisfactorily employed for making permanent color standards to match many varnishes, oils, lacquers, and resins. The darkest tube matches the color of 3 g. of potassium dichromate in 100 cc. of sulphuric acid (sp. gr. 1.84). In this set of standards each color is two thirds the intensity of the next higher color. The tubes are standardized at 25°C (77°F), but color determinations



made between 20°C and 30°C are substantially correct, since no appreciable change in color occurs within this range."

The tubes are placed in a wooden rack and a space between each standard is allowed for the sample under test. A sheet of diffused glass is placed at the back, and a protective metal shield is placed over the tubes. Optical comparison is made by viewing the color, through the glass tubes.

When used for measuring the color of a resin, the resin is dissolved in an equal weight of toluol or other water-white solvent and the color comparison made and recorded.

### **The Hellige Comparator**

This instrument is composed of a housing with a lighted background and a numerical color disc. Material to be tested is filled into a glass tube and placed in a holder within the housing. The color disc is revolved until the sample and standard color on the disc are comparable. The result is read direct from a figure seen through an opening in the front of the comparator.

### **The Pfund Multiple Reflection Colorimeter**

This instrument intensifies small color variations and makes it possible to distinguish and measure color differences which are barely perceptible to the unaided eye.

It is uniquely qualified to measure small deviations from neutrality of materials purporting to be white and is especially adapted to measuring white coatings, pigments, papers, textiles, glass, sugar, flour, etc.

The principle of Multiple Reflection may be explained by the following simple illustration, viz: If a beam of white light falls on a yellow surface, a relatively high percentage of the yellow component of the original beam will be reflected, whereas only a relatively low percentage of all other components will be reflected. If this once reflected light falls on a second yellow surface, the ratio of the yellow light to the total of the other component will be further increased. It is evident that if this process of selective reflection and absorption is continued a number of times, the percentage of yellow light in the finally reflected beam will be greatly intensified.

The application of this principle in the Pfund Multiple Reflection Colorimeter can be explained by the following references to the accompanying diagram. (See illustration No. 46.)

Here *L* is a powerful Mazda C lamp which illuminates the outer portion of the circular disc *A*, whose upper surface is covered with the material to be studied. The light, diffusely reflected, illuminates the lower (similarly coated) surface of the disc *B* which, in turn illuminates the central portion of the disc *A*. The light, after multiple

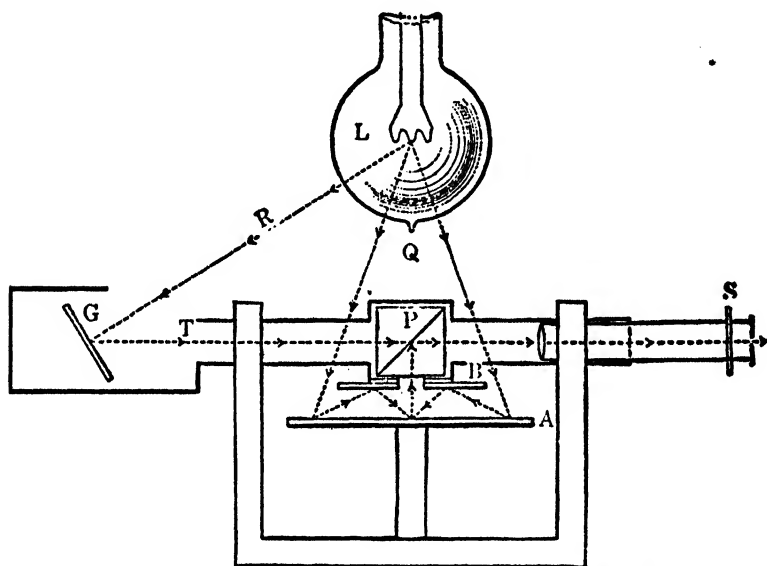


FIG. 46. Colorimeter

*Munsell Color Co.*

reflections, passes upward through a central opening in *B* and is reflected horizontally by means of the photometer cube *P*.

Another beam of light leaving *L* is reflected from a disc of roughly ground, clear optical glass *G* (briefly it may be stated that the most painstaking tests have shown that such a plate reflects visible radiations non-selectively). This light passes through the tube *T* and fills the upper half of the field of view of the photometer cube which has a horizontal line of demarcation and which is viewed through a simple eyepiece. The intensity of this beam is varied by rotating the disc *G* about a horizontal axis. A pointer, attached to the rod, bearing

disc G, moves over a graduated scale which is calibrated in terms of relative illumination.

Five colored glass filters (red, yellow, green, blue-green and purple-blue) are successively placed in the eyepiece tube at S and photometric balances are established in each case. The final results may be presented in the form of curves where abscissae represent dominant wave lengths of the color-screens and ordinates, reflections coefficient. (See also PHOTOMETER under TESTS.)

### Spectrometric Equipment

A spectrometer or spectrograph is an instrument designed to break up the light from a source into its constituent wave lengths and to provide a means of qualitative or quantitative study of the spectrum so formed.

The Recording Photoelectric Spectrophotometer, as described by the General Electric Company, is "A high precision instrument that provides a very reliable, time saving method of making graphic measurements of any color that the human eye can perceive.

"It is used wherever an exact knowledge of color composition is necessary. One important field of usefulness is in cataloging the curves of different dyes, inks, and pigments. It is also used to match colors, to measure fading and opacity and to record the colors of competitive products.

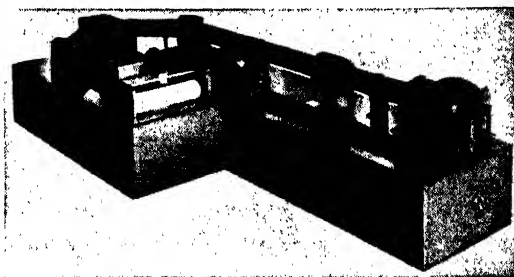
"The spectrophotometer furnishes: (a) an accurate and permanent graphic analysis of any color. The data thus obtained make possible the production at any time of new colors with predetermined characteristics. As a result, more uniform high quality products can be made. (b) Pigments and vehicles can be mixed in such proportions that any color can be matched exactly. (c) It affords an easy means of standardizing colors. (d) It provides a reliable method of accurately identifying the basic materials used in any color mixture.

"The Recording Photoelectric Spectrophotometer (see illustration No. 47) is used to make spectral reflectance or spectral transmission measurements of a variety of materials. Reflectance values are expressed as a percentage of the selected standard. Transmission is expressed either directly or as a percentage of a standard transmission sample. The speed and accuracy with which measurements

can be made make this instrument a very valuable tool for studying many color problems. Essentially, it consists of a monochromator, a photoelectric photometer, and a means of graphically recording their respective values.

“ Since this is a recording instrument, it does not require the services of an operator with specialized training in optics. As it uses a phototube, it has ample sensitivity at the violet end of the spectrum, where visual spectrophotometers must always fail because of the low visibility of violet light.

“ The Recording Photoelectric Spectrophotometer is of great value to many industries in which control of color is necessary. Color control is of basic importance in the making of inks, lacquers, paints, dyes, and paper.



*Gen'l Electric Co.*

FIG. 47. Spectrophotometer

“ One of its most important uses is in cataloging the curves of different dyes, so that new colors with predetermined characteristics can be obtained at any time by the proper mixture of standard dyes already at hand.

“ It should be remembered that the recording photoelectric spectrophotometer is a laboratory instrument, and is best used to accurately control the basic materials entering into the manufacture of colored products.

“ **MONOCHROMATOR** — The monochromator is a double prism type, which assures a high degree of spectral purity. It is equipped with bi-lateral slits which are automatically adjusted for a wave length band of 10 millimicrons within the wave length range of 400 to 700 millimicrons.

“**PHOTOMETER** — The photometer combines the polarization method of photometry with a photoelectric balancing scheme in such a manner that such factors as light source characteristic and phototube and amplifier sensitivity are eliminated from the measurement.

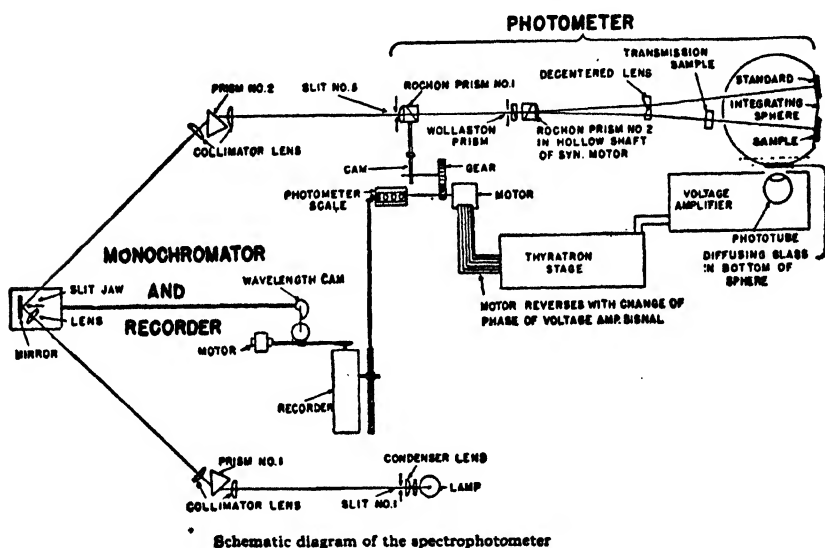
“**PHOTOMETER CAMS** — In addition to the regular 100 per cent cam, which is employed to translate the Rochon prism angle to per cent transmission or reflectance, a five times cam is also included which expands the readings below 20 per cent to five times their normal values. This cam is useful in showing small differences between dark samples. Two more cams can be added to plot special functions of reflectance or transmission, such as density and log functions. The desired cam is easily selected for use by sliding the camshaft to the proper position.

“**RECORDER** — The recorder is of the drum type. The wave length scale is  $6\frac{1}{4}$  inches long, and the photometric scale is 10 inches long. Two recording speeds are available,  $2\frac{1}{2}$  minutes and 5 minutes. The latter is used when measuring very selective samples.

“**PRINCIPLE OF OPERATION** — In the schematic diagram (see illustration No. 48), the collimator lenses and prism No. 1 produce a spectral image of slit No. 1 in a vertical plane normal to the mirror at the second slit. A portion of this spectrum is imaged by collimator lenses and prism No. 2 on slit No. 3.

“Monochromatic light from slit No. 3 is plane-polarized by Rochon prism No. 1. The Wollaston prism generates two components, mutually perpendicularly polarized, which fall on standard and sample, respectively. Rochon prism No. 1 is mounted in a bearing and is rotated by a cam arrangement. The angular position of this Rochon prism with respect to the Wollaston prism determines the ratio of the energy distribution in the two beams and hence, as will be shown later, is a measure of the reflectance of the sample in terms of the standard. Rochon prism No. 2 is mounted in the hollow shaft of a synchronous motor. The rotation of this element serves to vary the light intensity of the incident beams from minimum to maximum on the sample and on the standard, out of phase with each other. A phototube views a frosted glass in the integrating sphere wall, the brightness of which is a function of the sum of the product of beam intensity and reflectance for both sample and standard. When the light reflected

from the sample and standard is not equal, an alternating current component is present in the phototube current. The phase of this alternating component with respect to the voltage applied to the synchronous motor determines which of the two reflected beams is the more intense. This amplified alternating component is then used to control, by means of the thyatron stage, the direction of rotation of the balance motor. This motor readjusts the Rochon prism No. 1 to obtain a redistribution of energy in the sample and the standard beams, thus removing the alternating component in the phototube



Gen'l Electric Co.

FIG. 48. Spectrophotometer

current. The angular position of Rochon prism No. 1 is then a measure of the reflectance of the sample in terms of the standard.

"The illumination on the sample and the standard is normal to the surfaces and covers a portion one inch in diameter. The frosted glass in the integrating sphere wall is symmetrically located with respect to the sample and the standard positions.

"Transmission measurements are made by using a sample and a standard of the same material and introducing the transmission specimen in the incident sample beam. Provisions are also made for

placing a standard transmission specimen in the standard beam. Transmission samples up to 5 cm. in length can be accommodated.

"As can be seen from this description, the light incident on the sample and the standard is derived from the same source, thus eliminating from the measurement the characteristic of the source.

"Furthermore, the optical system is common to the sample and the standard, with the exception of one pair of decentered lenses, which is used to obtain wider angular deviation of the sample and the standard beams. Since the voltage amplifier and the thyratron stage amplify alike the current due to the light from both the sample and the standard, the measurement is independent of the characteristics of these units. As only monochromatic light reaches the phototube, the spectral response characteristic of the phototube does not enter into the result."

### Hiding Power

When colored lacquers or synthetic enamels are brought to the control laboratory for test, it is a part of the control to check the covering capacity. The material is sprayed over surfaced paper to determine the covering power.

Large glazed and semistiff cardboard paper is surfaced with two parts white lacquer surfacer and one part cream lacquer enamel. This surfacing material is applied by spray and when the sheets are dried, they are cut to 6"  $\times$  12" sizes. A 3½ inch band of coach black (black in Japan) is brushed through the horizontal center section to show the contrast of dark and light colors. The surfacing of the paper insures its non-absorptive qualities.

A film spinning device is often used to check the covering or hiding power of pigmented finishes. In conducting this test, heavy glass plates 4½"  $\times$  4½" are used which are placed on a revolving disc. A checkerboard paper is secured to the glass plate, and the material is placed on the paper and is then set in motion on the revolving disc. A definite amount of coating is applied and calculations are drawn from the amount of material required per unit area, after first determining the loss of a known weight of the liquid upon drying.

### Pfund Cryptometer

The Pfund Cryptometer is a simple compact instrument for accurately measuring the thickness of a film of coating material necessary to completely obliterate any background upon which it may be spread. The convenient table supplied with each instrument enables one to quickly convert Cryptometer readings into hiding power, expressed in terms of square feet hidden per gallon of coating used, or square feet hidden per gram of pigment, thus offering a direct means of quickly obtaining complete hiding power data which is comparable to actual paint-out tests.

The Cryptometer consists primarily of two plates of glass whose optically flat surfaces are separated by a fixed angle in which a wedged shaped film of coating is formed. The bottom plate of glass is opaque and is fitted with a convenient arrangement for determining and measuring the thickness of the film of coating necessary to completely hide an underlying surface. The top plate is transparent and fitted with metal pegs for maintaining a constant angle between the two plates. A wedge shaped sample, of the material to be tested, is formed between the top and bottom plates. Where the layer of finishing material has sufficient thickness, the background will be completely hidden. By sliding the top plate back and forth, a sharp line of demarcation (showing the point of complete hiding) alternately appears and disappears. The point of appearance and disappearance, of the line of demarcation, is read on the engraved millimeter scale.

The Cryptometer is furnished in two styles, namely: "Black and White Cryptometer" and "Well-Type Cryptometer."

The bottom plate of the "Black and White Cryptometer" is made up of two pieces of opaque glass (one white and the other black), cemented together. This instrument can be used to measure the *hiding power* of lacquers, paints and pigments of all colors, including all the chromatic colors, the blacks, the whites and the grays. Two top plates with wedge constants .0007 and .0002 respectively are furnished with this instrument. (See illustration No. 49.)

The salient points of this instrument are as follows:

*A* — Metal base.

*B* — Opaque black glass, reflection factor less than 8% ( $\frac{1}{3}$  bottom plate).



- C* — Opaque white glass, reflection factor 80% or 2 ( $\frac{1}{3}$  bottom plate).
- D* — Transparent glass top plate.
- E* & *F* — Groove in bottom plate to allow for overflow of material.
- G* & *H* — Groove in top plate to allow for overflow of material.
- I* & *J* — Metal pegs ground to produce proper angle between plates.
- K* — Millimeter scale.
- L* & *M* — Sharp line of demarcation between hidden surface and surface which is not hidden.
- X* — Distance in millimeter to be read on scale *K* at appearance and disappearance of sharp line *L-M*.

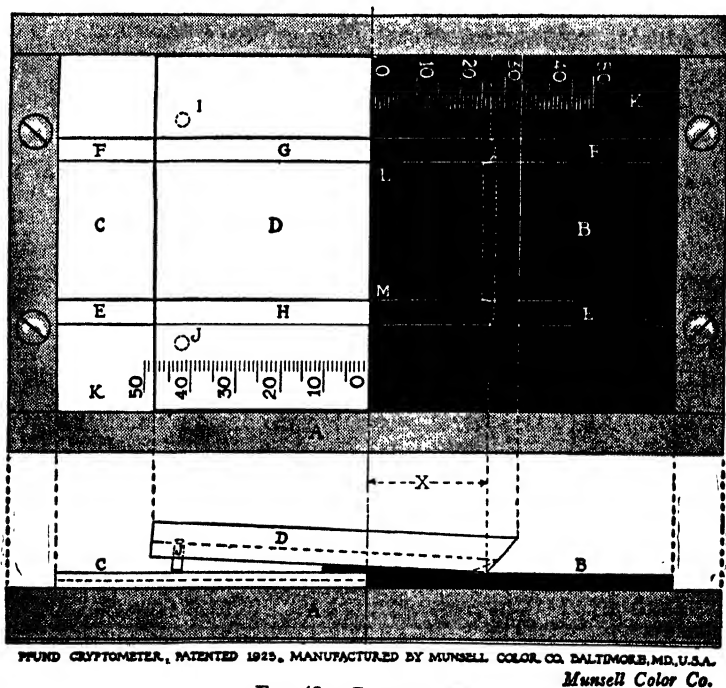


FIG. 49. Cryptometer

### Nigrometer

This instrument is an adaption of the Intensometer and is used to measure, comparatively, the amount of light reflected from a black surface. This is accomplished by intensely illuminating the surface

of the sample under test. By means of a movable standard light source, to which a scale is attached, the amount of reflected light from the sample may be balanced. The position of the movable light when balanced thus enables the operator to read the scale and thereby give a numerical value to the black under test.

The Nigrometer is used expressly for wet black coatings. The black is rubbed up in oil and transferred to a clean glass slide. This slide is placed in a horizontal position on the Nigrometer where its scale value may be determined. Scale readings for color-blacks cover the range of 50 to 70.

### **Film Discoloration**

Clear lacquer and resinous varnish films are subjected to discoloration by light and by gas. Of these two mediums, the former is considered of more general importance.

The Hercules Powder Company, in their 1933 paper on "Relative effect of nitrocellulose, gums and plasticisers on discoloration," have indicated that films of nitrocellulose alone do not discolor to any great extent under ultraviolet light. Films of nitrocellulose and plasticiser or of nitrocellulose and resin show greater discoloration as the component (other than nitrocellulose) in the binary system is increased.

Discoloration values of such clear films are enacted by spraying definite film thicknesses, age for one week in the dark, and then exposing the plates to the Uviarc. Color can be measured with the Pfund Multiple Reflection Colorimeter.

### **Gas Discoloration**

The gas discoloration tests are made under a large ball jar. Precaution as regards uniform and continuous flow of the gas is necessary. A cylinder of  $\text{SO}_2$  is generally used as the source of gas. This discoloration test is also applicable to white synthetic enamel refrigerator finishes.

### **Accelerated Pimpling Test (Motor Car Lacquer Finishes)**

This test was devised by a manufacturer of motor cars as an attempt to duplicate results encountered on lacquered surfaces of

cars placed in a large storage building where an accumulation of exhaust gas fumes were combined with a damp atmosphere. This condition caused the formation of minute blisters or pimples to form over the lacquer finish.

New panels of body steel 4"  $\times$  8" are used in the test. Aluminum panels give more uniform results, but in an attempt to track down the cause of this condition, panels of regular steel body material were used. The greatest of care should be exercised in cleaning the panels — *this is important*. The panels should be sanded and re-cleaned immediately prior to lacquer applications. Finger marks on metal or enamel will cause a rapid breakdown unless they are removed. The lacquer enamel is applied directly to the panels; two double coats being used. Fifteen minutes is allowed between the first and second double coat application. The second coat is air-dried and then placed in an oven and heat-treated for thirty minutes at 175°F and allowed to cool for fifteen minutes. The panel is then water-sanded with 320–400 paper (wet or dry type) and followed with rubbing compound and polish. A brush application of clear brushing lacquer is applied to the edges and reverse sides.

A small wooden rack is prepared to hold sufficient panels to be tested and still of sufficient size to fit into a five gallon kit. The kit is filled with cold water and the rack containing the panels is placed into the kit. The cover is placed on the kit and the kit is inverted into a larger container. The cover is removed and the panel rack is erected on bricks which raises the rack up into the kit. A hose is connected to the exhaust pipe of a motor car and the other end of the hose is placed under the inverted kit. The car's motor is started which permits the exhausted fumes to replace the water under the inverted kit. The exhaust gas is permitted to pass into the kit until satisfied a well saturated atmosphere is present. Panels are removed, dried, and examined under a low power microscope. It is advisable to run a check panel, that is, one which from previous experience has pimples when so exposed.

### Hardness

The PFUND HARDNESS METER is one of the most satisfactory instruments which has been designed for determining the hardness of

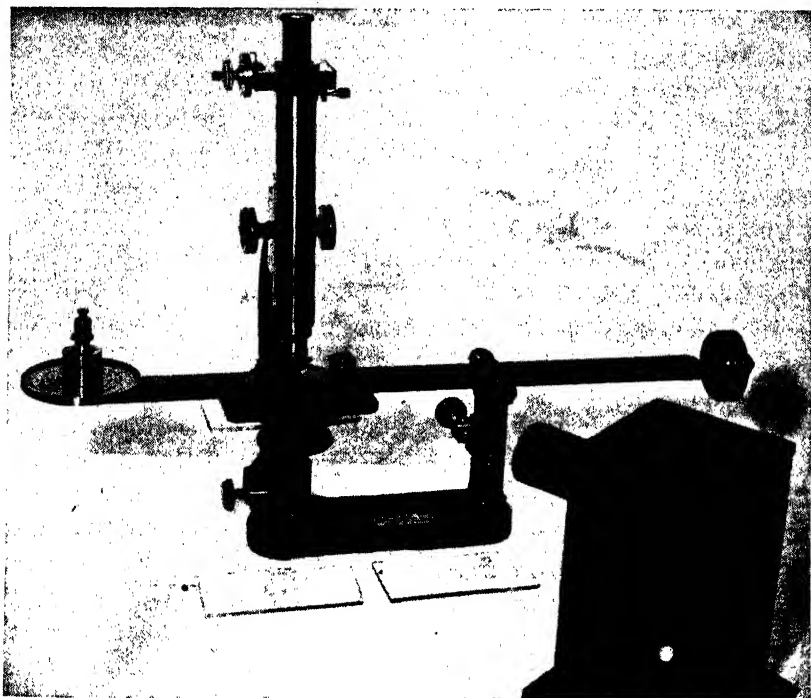


FIG. 50. Hardness meter

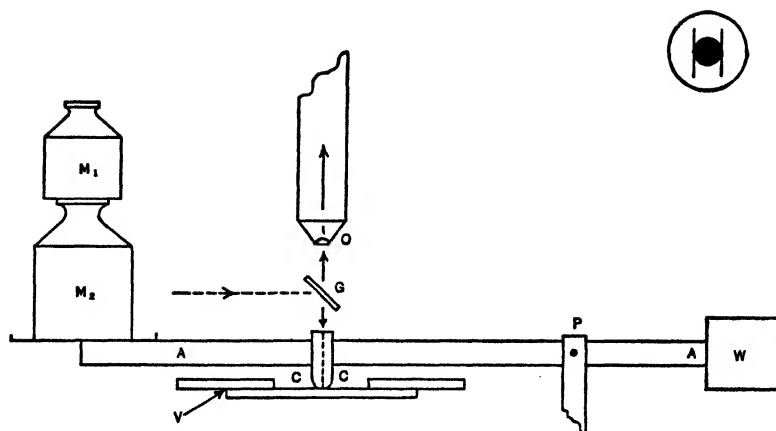


FIG. 51. Hardness meter

lacquers, varnishes, or other plastic films. It has proved thoroughly reliable for all types of surfaces. Even for those surfaces, in which the "top tack" exists, this instrument gives results which parallel the findings of practical lacquer or varnish men using the finger-nail test.

All measurements are made at the time of actual contact between the tool and the film, thereby eliminating any error caused by the resilience of the film.

The general disposition of the apparatus is evident in the accompanying sketch. A brass beam *AA* is pivoted at *P* and is supplied with a counterweight at *W*, which serves to balance the beam in the absence of the weights *M1* and *M2*. Impression of the coating film *V* is made by means of a transparent circular cylinder of crystalline quartz *C* which is of  $\frac{1}{4}$  inch diameter. The lower surface is accurately ground and polished to hemispherical form while the upper is flat and is inclined to the horizontal by 4 degrees.

For purposes of viewing, a piece of clear glass is mounted at *G* so that a horizontal beam of light from the special light source included with the instrument, may be directed downward through the quartz cylinder, where reflection takes place at the hemispherical surface. The returning beam enters the microscope—the character of the phenomena under observation being shown in the insert at the upper right hand corner of the diagram. The diameter of the circle of contact between the hemispherical surface *C* and the coating film is measured with a micrometer eyepiece.

Instead of measuring the diameter of the circle of contact for a constant load *M*, it has been found that a much greater dispersion of results could be obtained by varying the load until a circle of fixed and predetermined diameter was produced. The actual diameter agreed upon was three divisions in the micrometer eyepiece. Rather than find the exact load required, it is more expedient to put on loads yielding diameters, respectively, too small and too great. By recording both loads and diameters, it is possible to calculate the exact load by simple interpolation. (See illustrations Nos. 50 and 51.)

### Sward Hardness Rocker

According to the Henry A. Gardner Laboratory, "This device consists essentially of two 4-inch metal rings spaced 1 inch apart by

means of studs, a pendulum or pointer suspended between the rings at the top and a scale at the bottom for indicating the motion of the pendulum.

"The principle of the rocker is that the harder the surface or film, the longer it will rock after being set in motion. Values obtained on films are compared with those obtained on polished plate glass.

"*Operation:* The film whose hardness is desired is prepared on polished plate glass by flowing, brushing, spinning, spraying, wiping with a doctor blade, etc. Dust or lumps in the film should be avoided. When ready to test, the panel is supported on a leveling table. If none is available, three lumps of molding clay may be used. The rocker is set on the film and adjustments made so that the pointer hangs over the center mark of the scale. Two adjustments are made at right angles to each other. Spirit levels are unnecessary.

"The rocker is then rolled to the left until the pendulum just touches the left stop and is then gently released. Counting is begun after the last contact of the pendulum with the stop. The number of times the pendulum returns to or beyond the line on the left half of the scale, multiplied by two, is the value sought. The sum of two successive determinations may be made." (See illustration No. 52.)

**The Scratch Tester** (as used by Underwood-Elliott-Fisher Company) or an instrument of similar design is employed by the coating industry. This device consists primarily of a weighted arm with a phonograph needle attachment. This is passed to and fro over the coated surface until the film has been ruptured. A direct reading from the instrument in weight required to scratch through the film can be read and recorded.

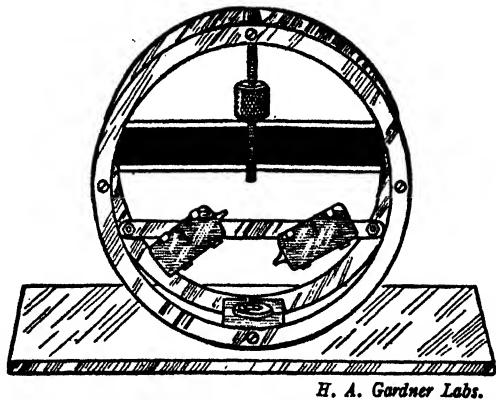
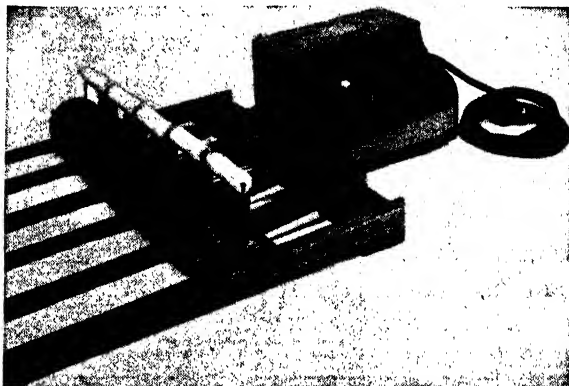


FIG. 52. Sward hardness rocker

### Drying — Printing

Touching the film with the finger to determine drying has been replaced by such instruments as Dry-O-Graph and whirling discs with flowing sand.

The Parks Dry-O-Graph is a practical drying instrument which consists of a track in which strips containing the drying films are placed, a roller to press a strip of cotton flannel upon the drying film, and a telechron motor to pull the roller over the film. (See illustration No. 53.)



*Parks Laboratory*

FIG. 53. Drying meter

In operation, films are prepared on the tin plate test strips. (The Film-O-Graph is recommended for this purpose, as films of identical thickness may be made.) If only one material is being tested, place an uncoated strip in the track so that the roller will not tilt. Place the roller on the film with the loose end of the flannel between it and the film. Connect to the motor and start the motor. The flannel is thereby applied to the film at the rate of one linear inch per hour (an auxiliary wheel is furnished, which will apply the flannel at the rate of 12 inches per hour for use with rapid drying materials, such as lacquers).

When the test is completed, detach the flannel from the test strips. The drying time is measured in inches of the adhering lint.

Once the test is started, it requires no attention for 24 hours,

(except where lacquers are under test), but may be stopped at any time.

### Drying Meter Cabinet — Sandometer

This test is conducted in a humidity and temperature controlled cabinet or room. The lacquer under test is applied to a glass plate by spinning, which assures a definite film thickness. With the machine rotating at a constant speed, sand is flowed from a suspended cone



*DuPont Co.*

FIG. 54. Drying test

which travels slowly from the edge to the center of the disc, leaving a spiral trail of sand upon the coated film as the disc rotates. A material of known performance is used as a standard.

After the lacquer has thoroughly dried, the disc is turned upside down and tapped to loose small grains of sand. If the film is soft or tacky, the sand will adhere to the coating.

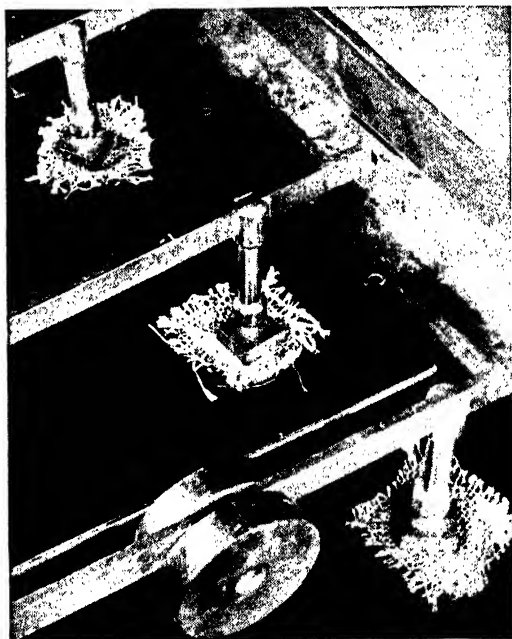
Values are determined at the dust free, tack free, and final drying time points. (See illustration No. 54.)



### Printing Test

Printing marks, caused by burlap, wrapping paper or braces used in crating, have long been a source of considerable worry to manufacturers.

In the test for printing, the lacquer or synthetic enamel is applied to panels in accordance with existing finishing schedules, thoroughly dried (or baked as the case may be) and placed in a horizontal



*DuPont Co.*

FIG. 55. Printing test

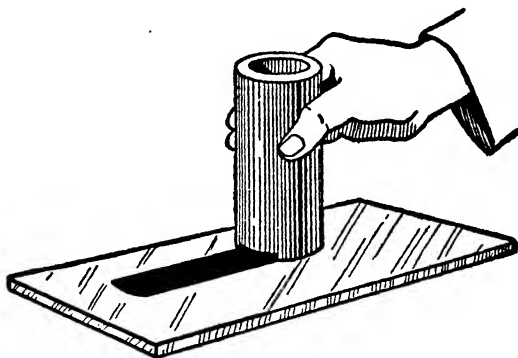
position on the test base. The fulcrum of a lever rests on a small metal block one square inch in area and a square of burlap is placed between the block and the coated panel. Weights are added to the free end of the lever until an impression has been made on the film. A material of known value is used as a standard. (See illustration No. 55.)

A similar print test resistance concerns the performance of the finish after it has been packed in a crate, in shipping and in storage,

where the finish may be subjected to pressure at elevated temperatures. Test is made by placing a piece of burlap and a 1½ pound weight on the finished panel and then subjecting it to oven heat at 120°F. The extent of printing at various periods is noted.

### Film Thickness

The evaluation of certain test properties as regards coating films is dependent on the production of films of definite thicknesses. Adhesion-flexibility tests as example will give variable results when bent over a mandrel if the film thickness is not constant throughout the test. In like manner, the impact test will show inconsistent results if films of definite thicknesses are not used.



*H. A. Gardner Labs.*

FIG. 56. Film-o-graph

The Parks Film-O-Graph is used and of this instrument, the Henry A. Gardner Laboratory quotes the following, "The Film-O-Graph is a chromium plated bronze cylinder with a milled channel cut in the end, through which the coating material flows. A plunger for use with materials of thick consistency is provided. With this device, colored coatings can be applied to flat surfaces, such as tin plate, glass or paper, in a predetermined exact thickness which is controlled by the milled steps in the ends of the cylinder.

"In the operation, place the panel that is to be coated on a perfectly flat surface, allowing about one-half inch of the panel to project over the edge of the surface. Place the Film-O-Graph upright on the

panel about one inch from the end; the channel should face the end. The coating material is put into the cylinder and the plunger is slipped into the cylinder and permitted to settle down on the material. Hold the cylinder down firmly on the strip with one hand *throughout the entire test*, and with the other hand draw the panel, not too fast, not too slowly, *without stopping*, until the other end of the strip is reached.

"The wet film on the panel will be .001 or .003 inch thick, depending upon the end of the cylinder used." (See illustration No. 56.)

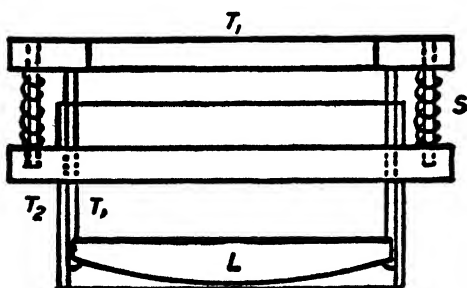
### Pfund Film Gauge

The Pfund Film Gauge is a simple instrument by means of which the thickness of wet coatings may be quickly and accurately determined. It is of particular service in measuring and controlling the thickness of coatings applied by the spray gun or sheet metal rollers.

The film gauge enables one to easily determine the shrinkage of such films upon drying (the thickness of the dry film is usually obtained by means of a micrometer or a dial upright gauge) and when used in combination with the Pfund Cryptometer to determine

the number of coats required to produce complete "hiding."

Essentially, the instrument consists of a spherical, convex surface which is forced through the coating layer. If the radius of curvature of the convex surface is known, a simple relationship can be established between the diameter of the circular lacquer or enamel spot and the thick-



Munsell Color Co.

FIG. 57. Film gauge

ness of the original lacquer or enamel film.

The general plan of the film gauge is shown in the diagram. (See illustration No. 57.) A convex lens  $L$  whose lower surface has a radius of curvature of 25 cm., is mounted in a short tube  $T_1$  which

slides freely in an outer tube  $T_2$ . The compression springs  $S$  keep the convex surface out of contact with the coating film until pressure is applied to the top of  $T_1$ . The instrument is simply rested on a coated surface and the lens is forced down as far as it will go. Upon releasing the pressure before removing the gauge, a circular spot is left on the gauge as well as on the coated surface. The diameter of the spot on the gauge is measured to 0.1 of a millimeter by means of a steel scale which is furnished with the instrument. If the spot is elliptical, the mean of the major and minor axes is determined. A series of ten readings over a given area yields a fair average of the thickness of the film. By referring to the table supplied with the instrument, the thickness of the coating film in millimeters, as well as the number of square feet which would be covered by one gallon of the coating at that thickness, may be evaluated at once.

A number of experiments have been carried out to check the accuracy of the film gauge. In each case a known mass of coating was spread uniformly over a definite area of plate glass and the thickness of the film was calculated in the usual manner. Different gauges and thickness of layer were used and the results are briefly expressed in the following table:

|                                             | 1      | 2      | 3      | 4      |
|---------------------------------------------|--------|--------|--------|--------|
| Film thickness by calculation (mm.) . . . . | 0.0444 | 0.0402 | 0.0644 | 0.0638 |
| Film thickness by film gauge (mm.) . . . .  | 0.0390 | 0.0390 | 0.0652 | 0.0638 |

Equally satisfactory agreements were obtained on varnish films. The difference between the calculated results and the measurements by the film gauge rarely exceeded 3%.

The highest accuracy is obtained when the lacquer or synthetic enamel is grainless and the underlying surface is smooth, flat, and non-porous. Grit in the coating or roughness in the surface to be coated will have some effect on the accuracy. However, the errors from such causes are not sufficiently large to affect the practical interest of this instrument to painters.

**A Doctor Blade or Scraper** is employed by certain investigators. This method, however, is used more frequently in oil paint film investigation (18).

## Gloss

The gloss of a protective coating is rather difficult to express. Customarily an optical set-up which consists of an instrument for determining the spectral distribution curve of reflection within the limits of the visual spectrum is used. There are several recognized instruments employed in the coating industry, notably: The Munsell Photometer, The Ingersoll Glarimeter and The Hunter Multi-purpose Reflectometer.

### Munsell Universal Photometer

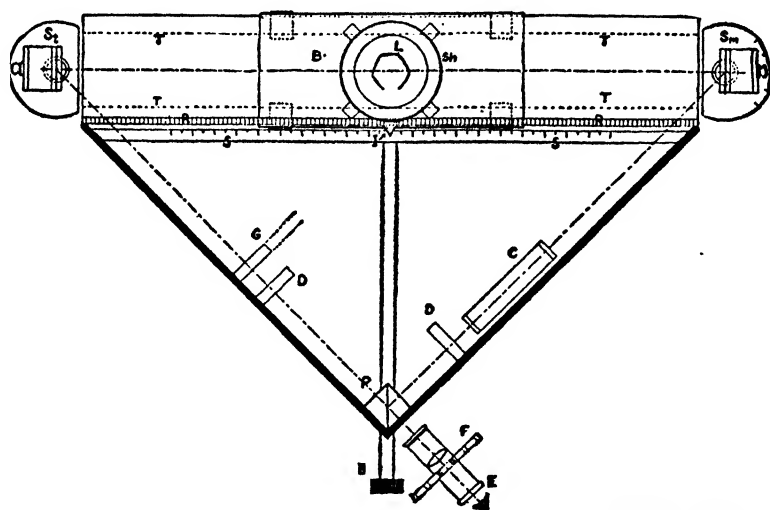
The Munsell Universal Photometer is a convenient colorimetric photometer which is equally suitable for measuring papers, textiles, glass, paints, pigments, or dyestuffs. The photometer is especially adapted for measuring the reflection factors of opaque samples in artificial daylight or normal Mazda illumination, at various angles of illumination and observation. It will also measure the transmission factors of liquids, solutions, glass filters, or other transparent materials. The Munsell Universal Photometer is equipped with five standard colored glass filters, whose dominant wave lengths are approximately 635, 585, 550, 495 and 455 millimicrons. By plotting the photometric readings obtained through these five filters, a simple spectral reflection or transmission curve is obtained.

The Munsell Universal Photometer furnishes a measure of gloss because of the provision for adjusting the sample at different angles with respect to illumination and viewing. Thus two photometric readings may be obtained, one with the sample at an angle where a minimum of specular reflection is observed, and the other with a maximum of specular reflection. The ratio of these two readings is a reliable indicator of the gloss of the sample.

In this instrument (see illustration No. 58), the sample placed vertically in the sample holder *Sm*, is compared by means of the photometric cube *P* with the standard, placed vertically in the standard holder *St*. By means of an eyepiece *E*, the two fields corresponding to sample and standard are viewed side by side. The holder *Sm* may be rotated about the vertical axis through its center.

The sample and standard are illuminated by the incandescent lamp *L* enclosed in a shield *Sh*. The lamp is mounted on a carriage

*B*, which moves laterally over the track *TT*. By means of the handle *H* and a gear meshing with a rack *RR* and the carriage *B*, the lamp is moved toward or away from sample or standard as desired, until an equality of brightness between the two photometric fields is obtained. An indicator *I* at the base of the lamp carriage points out the reading on the scale *SS*. For measuring the transmission of liquids a cell *C* is provided which rests on the base of the photometer box. For measuring the transmission of glass filters and other transparent



*Munsell Color Co.*

FIG. 58. Photometer

materials, a slot and groove *G* are also provided. For obscuring the effect of any pattern on the sample and to prevent glare from glossy samples, diffusing screens *DD* are provided on both sides.

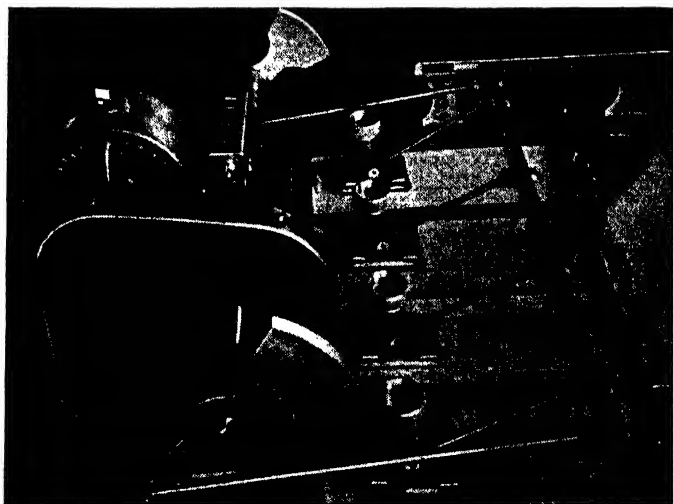
Between the eye and the photometric cube is a holder *F* which contains seven glass filters. These filters may be interposed at will, depending upon the type of illumination desired. There is a daylight filter to provide artificial daylight and a plain glass filter to provide normal Mazda illumination. There are, in addition, five colored glass filters (red, yellow, green, blue-green, and purple-blue) which serve to convert the instrument into a Colorimeter. Successive readings through these colored filters provide the data for simple spectral reflection or transmission curves.

The Ingersoll Glarimeter is described in Circular 307, American Paint and Varnish Manufacturer's Association, issued April 1927.

The Hunter Multipurpose Reflectometer is described by a bulletin issued by Henry A. Gardner Laboratory, Inc., Washington, D. C.

### Grease Resistance Test

In testing lacquer and white synthetic enamel for grease resisting values; grease, fat, oleic acid, butter, lard, and lard oil are used as



*DuPont Co.*

FIG. 59. Grease resistance

lubricants. These substances often come in contact with the finish and cause it to soften and wear away. A grease resistance machine is used in determining this test value. (See illustration No. 59.)

This device has been developed and is used by a large lacquer and synthetic enamel manufacturer's laboratory. The panels are coated, thoroughly dried (baked if necessary) and are then inserted and firmly secured in a horizontal position on the machine. Grease cups attached to driving arms are filled with butter, lard, etc., and the felt pads, as the contact base of the movable part, are kept well lubricated. There are four spaces on the machine, two spaces being provided for panels of known resistance and two for materials under test.

The machine is set in motion and operated at the rate of 22 cycles per minute for 50,000 cycles (100,000 single strokes). During the operation the grease cups are frequently observed and kept well filled so that the pads are well saturated. After the 50,000 cycle run, determined on the recording counter, panels are examined for wear and discoloration and are tested for softness.

### Humidity and Drying Conditions

Many finishing troubles are directly traceable to three important factors, namely: humidity, temperature, and circulation of air.

HUMIDITY is defined as the amount of moisture of water vapor in the air at any time. The atmosphere has the property of holding varying amounts of water vapor and the maximum amount of water vapor that a given space can hold at one time is always the same. When the maximum capacity, under a given set of conditions, has been reached, more moisture cannot be added without condensation taking place. Under such conditions the air is said to be "saturated." If that given volume of "saturated" air is taken and the temperature is increased, the capacity to hold water vapor will increase; with a decrease in temperature of the original volume, the excess moisture will be condensed until an equilibrium is reached by a saturated condition at the new temperature. The temperature at which the air is saturated is called the "dew point." With cold air this "dew point" is reached when there are only small quantities of water vapor present, but as the temperature of the air increases, the capacity for holding moisture is likewise increased. This quantity of water vapor in the air is called "humidity." When the quantity is expressed in grains of moisture per cubic foot of air it is said to be the "absolute humidity" of the atmosphere. The "absolute humidity" of saturated air increases very rapidly with an increase of temperature.

RELATIVE HUMIDITY — It has been found more convenient to express the amount of moisture in the air in terms of proportion of the moisture present to the amount of moisture the air could hold at that temperature. This is called "relative humidity" or the relation of the amount of moisture present to what it actually could be at that temperature.

There are several methods of determining relative humidity; wet



and dry bulb thermometer, hygrometer, psychrometer and such self-recording instruments as the Carrier Dew Point Control. This latter control is an automatic means of an expansion thermostat exposed to the air at the instant of saturation in the conditioning machine.

The "wet and dry bulb" thermometer is used to a large extent. This instrument is composed of two Fahrenheit reading thermometers. One of these is termed "dry," the other "wet." This latter is kept wetted by a water saturated wick which is attached. As the water evaporates, a cooling effect is noticed on the wet thermometer which in turn lowers the reading to a point lower than that shown on the dry thermometer. The particular atmospheric condition of a finishing room, etc., has bearing on the evaporation of this water in the wick attached to the wet bulb. As the readings are noted, the relative humidity is determined by consulting a chart. (See illustration No. 60.)

TEMPERATURE is necessary in order to have humidity control. Humidity control, however, may be had at temperatures lower than are advisable for finishing room or kiln. Just as water will evaporate more quickly at a higher temperature, so will the volatile thinners in a lacquer or similar finishing material be driven off more readily and the drying time hastened if the temperature is kept uniform and reasonably high. By controlling temperature, the same conditions can be obtained the year round in a finishing room, which is a vital factor both from the standpoint of economy and lessening of possible causes of trouble.

CIRCULATION OF AIR — The air in a finishing room, kiln, or drying room must circulate freely in order to carry away efficiently the volatile thinners as they evaporate, as well as to provide the best possible conditions for the workmen. By the same token, the air that comes in contact with the work must be fresh or a condition will be present similar to the action of a sponge that has absorbed all the water that it will hold. Poor circulation means the air will become saturated with the foul vapors and refuse to absorb more, thereby retarding drying. In addition, the available oxygen that is necessary in the drying of a coating film will be reduced and drying will be further delayed unless more oxygen is supplied in the form of fresh air.

| WET BULB READING • DEGREES FAHRENHEIT |    |    |    |    |    |    |    |    |    |      |     |
|---------------------------------------|----|----|----|----|----|----|----|----|----|------|-----|
| 70°                                   | 19 | 25 | 33 | 40 | 48 | 56 | 64 | 72 | 81 | 90   | 100 |
| 72°                                   | 16 | 21 | 28 | 35 | 42 | 49 | 57 | 65 | 73 | 82   | 91  |
| 74°                                   | 11 | 17 | 23 | 29 | 36 | 43 | 51 | 58 | 66 | 74   | 82  |
| 76°                                   | 8  | 13 | 19 | 25 | 31 | 38 | 45 | 52 | 59 | 67   | 74  |
| 78°                                   | 6  | 10 | 16 | 21 | 27 | 33 | 40 | 46 | 53 | 60   | 67  |
| 80°                                   | 3  | 7  | 12 | 18 | 23 | 29 | 35 | 41 | 47 | 54   | 61  |
| 82°                                   | 5  | 10 | 14 | 20 | 25 | 30 | 36 | 42 | 48 | 54   | 60  |
| 84°                                   | 1  | 7  | 12 | 18 | 23 | 28 | 33 | 39 | 45 | 51   | 57  |
| 86°                                   | 1  | 6  | 10 | 16 | 22 | 28 | 33 | 39 | 45 | 51   | 57  |
| 88°                                   | 4  | 7  | 11 | 16 | 22 | 28 | 34 | 40 | 46 | 52   | 58  |
| 90°                                   | 2  | 6  | 9  | 13 | 17 | 22 | 28 | 33 | 39 | 45   | 51  |
| 92°                                   | 8  | 7  | 10 | 15 | 19 | 23 | 28 | 34 | 39 | 45   | 51  |
| 94°                                   | 2  | 6  | 9  | 12 | 16 | 20 | 24 | 28 | 32 | 36   | 40  |
| 96°                                   | 3  | 6  | 9  | 12 | 15 | 19 | 23 | 27 | 31 | 35   | 39  |
| 98°                                   | 1  | 4  | 7  | 10 | 13 | 17 | 21 | 25 | 29 | 33   | 37  |
| 100°                                  | 2  | 5  | 9  | 12 | 15 | 19 | 23 | 27 | 31 | 35   | 39  |
| 102°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 31  |
| 104°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 31  |
| 106°                                  | 3  | 6  | 9  | 11 | 14 | 17 | 20 | 23 | 26 | 29   | 32  |
| 108°                                  | 2  | 6  | 7  | 10 | 13 | 16 | 19 | 22 | 25 | 28   | 31  |
| 110°                                  | 1  | 5  | 8  | 11 | 14 | 17 | 20 | 23 | 26 | 29   | 32  |
| 112°                                  | 1  | 5  | 8  | 11 | 14 | 17 | 20 | 23 | 26 | 29   | 32  |
| 114°                                  | 2  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27 | 30   | 33  |
| 116°                                  | 1  | 4  | 7  | 10 | 13 | 16 | 19 | 22 | 25 | 28   | 31  |
| 118°                                  | 2  | 5  | 8  | 11 | 14 | 17 | 20 | 23 | 26 | 29   | 32  |
| 120°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 122°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 124°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 126°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 128°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 130°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 132°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 134°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 136°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 138°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 140°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 142°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 144°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 146°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 148°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 150°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 152°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 154°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 156°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 158°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 160°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 162°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 164°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 166°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 168°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 170°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 172°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 174°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 176°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 178°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 180°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 182°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 184°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 186°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 188°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 190°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 192°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 194°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 196°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 198°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 200°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 202°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 204°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 206°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 208°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 210°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 212°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 214°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 216°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 218°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 220°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 222°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 224°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 226°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 228°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 230°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 232°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 234°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 236°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 238°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 240°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 242°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 244°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 246°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 248°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 250°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 252°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 254°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 256°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 258°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 260°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 262°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 264°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 266°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 268°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 270°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 272°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 274°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 276°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 278°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 280°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 282°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 284°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 286°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 288°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 290°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 292°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 294°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 296°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 298°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 300°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 302°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 304°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 306°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 308°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 310°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 312°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 314°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 316°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 318°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 320°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 322°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 324°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 326°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 328°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 330°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 332°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 334°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 336°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 338°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 340°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 342°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27   | 30  |
| 344°                                  | 1  | 4  | 6  | 9  | 12 | 15 | 18 | 21 | 24 | 27</ |     |

**HUMIDITY CONTROL** — Where the wet and dry bulb thermometer is used, the reading is taken after the apparatus has been placed in a given position for approximately one half hour. The regulating devices for controlling atmospheric conditions are termed: non-controlled, semicontrolled and absolute controlled. The non-controlled type includes such methods as: running water in troughs alongside of the room or passing the air over wet-wicks, sprinkling water or wet sawdust on the floor or spraying water into the air. The semicontrolled type, of which the average humidifiers are an example, is not capable of reducing the humidity but, however, does increase the humidity to a certain fixed point. The absolute controlled type is capable of reducing or increasing the humidity whenever it is desired. This latter type is most desirable.

Factors influencing the control of humidity are temperature and circulation of air. The average relative humidity should be about 40% as indicated by the wet or dry bulb thermometer or similar device. The dampers or fans should be controlled to secure air changes.

A constant humidity room is maintained by manufacturers of coating materials for the testing of lacquers, synthetic enamels, etc. The temperature and humidity are absolute controlled in this room and it is used for such tests as: drying time, blush test, hardness, flexibility, etc. This testing room is conditioned by equipment which maintains constant temperature and humidity throughout the year, thus making tests on one day exactly comparable with tests run on any other day.

Air conditioners are available which will control humidity, air-cleanliness, temperature and air motion in any industrial plant and for any industrial condition.

Humidity also affects the moisture content of wood. This subject is discussed under **FURNITURE FINISHING**, Part IV, Chapter XII.

For tests applicable to pigments, see Part I, Chapter VI.

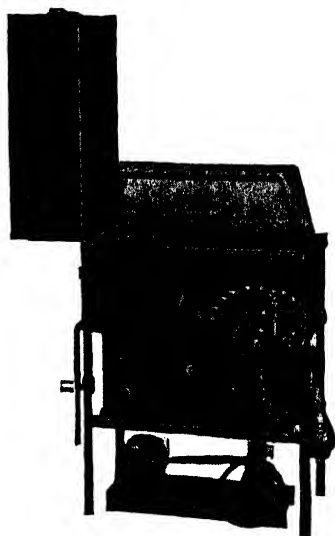
### **Salt Spray Test**

Where finishing materials are directly subjected to salt water immersion or salt water spray, as in the instance of certain parts of seaplanes, or where finishes are involved in close proximity to a

salty atmosphere, as exemplified by closeness to the seashore, such finishes are tested in a salt spray testing device.

Such a device is constructed of non-corrosive metal and the following salient features are noted (see illustration No. 61) :

- (1) One quarter horsepower equipped with protective switch, rubber covered cord and plug.
- (2) Compressor of sturdy construction developing  $1\frac{1}{2}$  cubic feet of air per minute, and 9 pounds of continuous pressure.
- (3) Separator — a three gallon up-right tank, placed under the cabinet. This tank is partially filled with 2 gallons of water, which should be changed weekly. As the air passes through this tank any oil from the compressor is eliminated, the air is cushioned for steady volume, and is cooled before delivery to the spray tip.
- (6) Drawer for salt water has ample holding capacity for several days operation.
- (7) Test cabinet of pure sheet nickle — the top half is hinged on one end and easily opened leaving samples being tested exposed to full view and easy to handle.
- (8) Rack with glass covered cross rods on which there can be no electrolysis from which to suspend samples.
- (9) Salt water mist surrounds parts being tested; there is no direct spray.
- (10) Drain for used salt water. Use the salt water only once to obtain accurate tests and to prevent contamination.



*Industrial Filter Co.*

FIG. 61. Salt spray test

The panels are coated, thoroughly dried, and are suspended from

a frame. The panels should be coated on the sides and back in order to arrive at a proper test value.

A salt spray tester in the form of a "trough" with a "slot" arrangement to secure the metal panels is also used. The salt water is sprayed from a fixed nozzle against a baffle plate and the salt mist is allowed to deposit itself on the coating.

### **Tensile Strength**

The maintenance of influences which govern expansion and contraction of a lacquer film, subjected to weathering and conditions under which it is serviced, has bearing on its durability, etc.

Tensile strength values involve a stress-strain test in which a film of definite thickness is applied to an amalgamated tin surface. After drying, stripping, and aging, it is placed in a machine to determine its ability to "stretch."

An apparatus known as an Extensimeter is used. This instrument consists of two movable racks with a needle indicator designating on a dial the distance at which the lacquer film fracture resulted (19).

A more recent version of an instrument for determining tensile strength is described by the Gardner Laboratory as follows:

**Tensile Strength and Elongation Apparatus** — "This apparatus, which was designed at this laboratory, is used to determine the tensile strength, elongation or distensibility, and elasticity of free films of coating materials. Films may be prepared in any suitable manner (such as on plate glass) and stripped. The films are cut into test pieces 1 cm. wide and about 12 cm. long. The test film is fastened to the upper and lower clamps which are adjusted to a distance of 10 cm. apart. The upper clamp is then moved upwards, stretching the film and the spring to which the lower clamp is fastened.

"The elongation or distensibility of a film is indicated on the scale at the upper right hand of the apparatus. The load is indicated on the scale at the lower left hand.

"Elasticity may be determined by releasing the load at various degrees of distensibility of the film and noting the degree to which the film returns to its original length.

"The effects of different kinds and amounts of ingredients, such as plasticisers, resins, and pigments in cellulose derivative films, as

well as the strength, elongation, and elasticity of oil, chlorinated rubber, and practically all film-forming media, may be determined quickly and easily.

“ The instrument is very compact and simple to operate, and has a wide field in the evaluation of raw materials. The results obtained

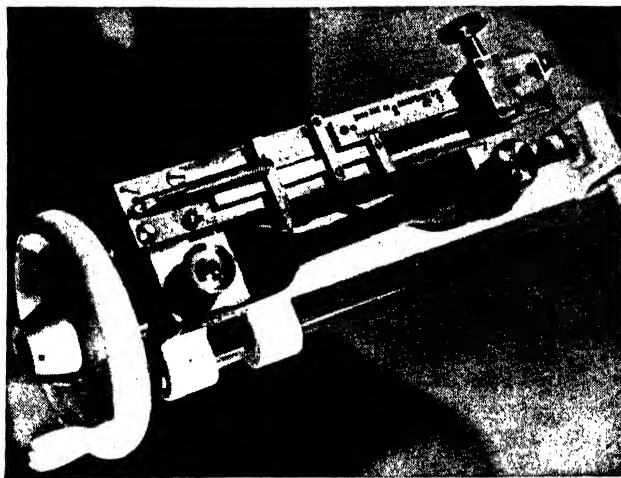


FIG. 62. Tensile strength test

*DuPont Co.*

may be correlated with such properties as exterior durability, resistance to bending, abrasion, imprinting, etc.” (Illustration No. 62 shows a type of tensile strength testing device.)

### Viscosity

Viscosity as defined by Webster is: “ The resistance of a fluid to the relative motion of its particles.” Viscosity is very important, since it is a determining factor of application of a lacquer, synthetic enamel, etc.

The lower the viscosity of a material, the lesser the internal friction and therefore the better the flow. There are times when high viscosity is desirable, which will apply to localized applications. In general, it is false economy to believe that heavy bodied lacquer is economical. What is most desired is a maximum of non-volatile and a minimum viscosity.

Lacquers are sold on the basis of their solid content, and reduction to arrive at applying consistency should be at a minimum. A knowledge of the viscosity of lacquers is essential, as this will permit adopting a standard.

Viscosity should not be confused with specific gravity, which is an expression of the weight relative to the weight of an equal volume of water, nor should it be confused with hydrometer readings.

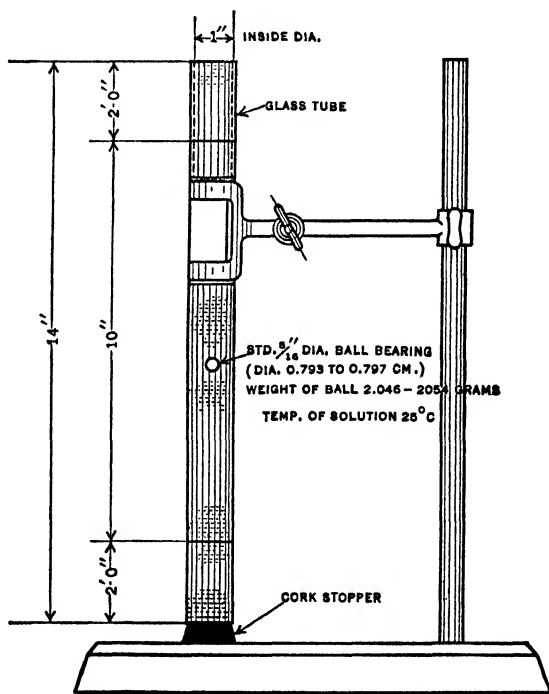


FIG. 63. Falling ball viscosity test

Standard means of determining viscosity should be adopted and limitations set up for a particular type of lacquer or synthetic coatings.

**Falling Ball Method** — While there are several methods used for measuring viscosity, the falling ball method (see illustration No. 63) is frequently used on heavy solutions, such as a nitrocellulose base. This equipment consists of a 14 inch glass tube, 1 inch inside diameter. The bottom end is stoppered and the material under test

is placed in the free end. Two indicator marks are filed 2 inches from each end and the solution is permitted to remain in the tube until the bubbles of air have risen to the surface. As the temperature of the solution has an important bearing on its viscosity, readings are taken at a standard temperature, usually 25°C (77°F). A steel ball bearing  $\frac{1}{8}$  inch in diameter (0.792–0.797 cm.) and 2.033–2.035 g. in weight is inserted in the top opening and the time required for the steel ball to travel the marked distance of 10 inches is taken as the viscosity reading. (Also see DETAIL OF VISCOSITY — TESTS FOR CELLULOSE ACETATE.)

The American Cyanamid Company quotes the following viscosities of nitrocellulose in solvent mixtures by the falling ball method at a temperature of 25°C (77°F):

“Twelve grams of 4 second nitrocellulose were dissolved in 100 cc. of solvent mixture consisting of 50 cc. toluol and 50 cc. of solvent. This represents 16 oz. of dry nitrocellulose to a gallon of solvent mixture.

| <i>Solvent</i>                 | <i>Time</i> |
|--------------------------------|-------------|
| Ethyl lactate, synthetic ..... | 7 seconds   |
| Cellosolve .....               | 7 seconds   |
| Butyl propionate .....         | 19 seconds  |
| Amyl acetate .....             | 16 seconds  |
| Ethyl oxybutyrate .....        | 12 seconds  |

The above test was repeated using 24 g. of dry  $\frac{1}{2}$  second nitrocellulose in 100 cc. of solvent mixture with the following results: This represents 32 oz. of dry nitrocellulose to a gallon of solvent mixture.

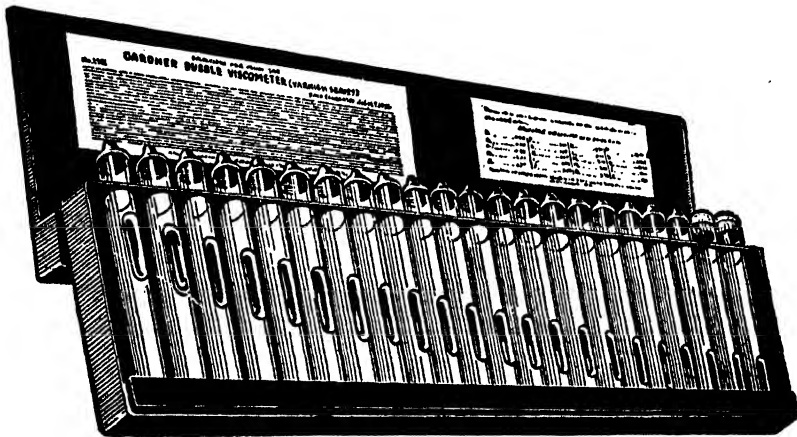
| <i>Solvent</i>                 | <i>Time</i>  |
|--------------------------------|--------------|
| Ethyl lactate, synthetic ..... | 9 seconds    |
| Cellosolve .....               | 7 seconds    |
| Amyl acetate .....             | 50 seconds   |
| Ethyl oxybutyrate .....        | 22.5 seconds |

**Stormer Viscosimeter** — The Stormer Viscosimeter employs a spindle suspended in a cup of the liquid being tested. This spindle is rotated by the energy supplied from a weight suspended by a cord from a wheel at the top of the spindle. A catch is released which causes the weight to fall and turns the spindle in the liquid. The



more viscous the lacquer or similar liquid, the slower will be the rotation. The time required for the spindle to make 100 revolutions is the viscosity reading. The temperature must be uniform and the cup properly filled.

**Doolittle (Torsion Type Viscosimeter)** — In the Doolittle, or torsion type viscosimeter, a weight is suspended by wire in the cup. The wire is twisted through a certain angle and released, causing the weight to twist back and forth in the liquid. A reading of the number



*H. A. Gardner Labs.*

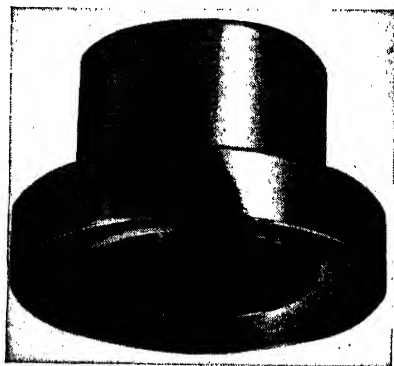
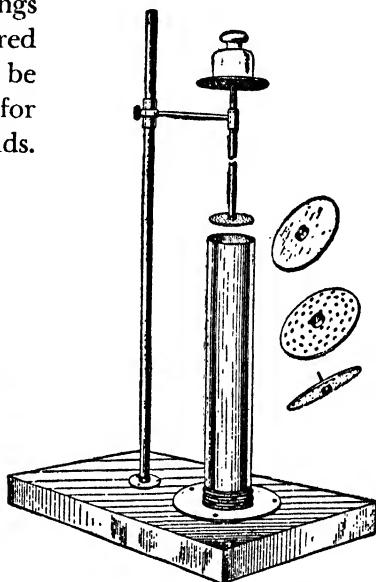
FIG. 64. Viscosity tubes

of degrees through which the spindle rotates is taken, and the reading is compared with that taken in a standard sugar solution of known concentration. This ratio is the viscosity reading for the material being tested. In this, as in other viscosity tests, temperature must be maintained at a predetermined constant.

**Gardner-Holt Tubes** — These are a series of sealed tubes which are filled with wax-free mineral oils. Bubble viscosity determinations are indicated on the top of the tube. For comparative viscosity determinations, blank tubes are filled and comparison is made with a standard. Here again, the temperature of the solutions must be constant. (See illustration No. 64.)

**Ford Cup** — This is a cylindrical cast-bronze cup which is tapered to a point and has a small hole at the bottom for material flow-out,

and is used for plant control purposes by users as well as by manufacturers of protective coatings. The cup is fitted into a stand and is equipped with an overflow ledge to insure a constant level before the viscosity is determined. The liquid is maintained at a definite temperature before it is placed in the cup and the hole is stoppered with the forefinger and released to allow the liquid to flow out into a receptacle. As the finger is released, a stop watch will record the time in viscosity reading required to empty the cup. The Ford Cup is quite practical and widely used and is available with special openings which may be attached to the tapered point when heavier liquids are to be used. It may be used equally well for colored liquids as for clear liquids. (See illustration No. 65.)

*Vol-U-Meter Co.***FIG. 65.** Ford viscosity cup*H. A. Gardner Labs.***FIG. 66.** Mobilometer (*obsolete model*)

**Gardner Mobilometer** — This instrument consists of a cylinder supported by a base plate, plunger or piston, and a bracket to support the plunger. (See illustration No. 66.) The plunger consists of a disc with fifty-one perforations  $\frac{1}{8}$  inch (1.59 mm.) diameter and a weight pan attached to the end of a brass tube. Two supplementary discs, which greatly extend its range, are supplied with the instrument. One is solid, the other has four holes (6.25 mm. in diameter).

The weight of the moving system, which includes the 51 hole disc,

piston rod, and weight pan is 100 g. In many cases it is desirable to use different loads on the plunger, and express the results as a load-time curve.

The cylinder is filled to a depth of 20 cm. with the material to be tested and is then leveled by means of the adjusting screws. The disc end of the plunger is then introduced into the cylinder and the bracket is attached. The time required for two marks 10 cm. apart on the piston rod to pass through the collar is then recorded. Some operators may prefer to use a greater length of travel, and this is easily done by making the required marks on the rod. The marks have previously been located so that they pass through the collar of the bracket as the disc passes through the mid portion of the cylinder. Thus the piston rod is in motion both at the beginning and end of the interval.

In performing the test, the piston rod is raised so that the punch mark on the rod is even with the top of the piston guide. The material adhering to the piston rod should be wiped off. This can be done with a piece of filter paper or lintless cloth while the rod is being withdrawn from the cylinder.

One method of recording the data obtained with the Mobilometer is to plot the total load against the reciprocal of time. Another method is to express the results as the product of the time and the load divided by the distance traveled. For viscous materials the expression will be a constant as in the following formula:

$$K = \frac{L \times t}{d}$$

where  $K$  = constant

$L$  = total load in grams

$t$  = time in seconds

$d$  = distance traveled in centimeters.

A sample of certified viscosity accompanies the instrument.

**Electro-Viscometer** — This instrument of recent introduction is a portable unit and an electrical device combined. It is fitted with a small motor operated from any single phase light circuit, and may be directly immersed into the liquid under test, thus obviating the

need for sampling. It is simple in operation, the switch being merely turned on and the device inserted into the liquid. When the agitator arrangement of the insert is started in motion, it indicates and records the viscosity on a dial. The viscosity is shown in visual scale units, the potential on the circuit being adjusted to a definite value by a control dial.

An increase in viscosity necessitates an increase in spraying pressure, and therefore reduces the volume of liquid sprayed. This influences the character of atomization, flow, orange-peel, blushing, and general behavior in the process of application. Most coating materials should be thinned by the user to applying consistency. Blue, black, and red pigments effect viscosity changes; probably due to oil absorption variance. White and yellow effect very slight changes while the storage of lacquer effects a change in viscosity. Alkali bodies, sunlight, or elevated temperatures also have an effect on viscosity changes.

In the logical formulation of lacquers, it is more advantageous to change the nitrocellulose concentration rather than alter the solvent composition; there is a close relationship between the solvent power of the solvent and the viscosity of the nitrocellulose solution.

Viscosity curves are illustrated (see Nos. 67 and 68).

### **Accelerated Weather Tests**

In the laboratory development (and in actual practice) of lacquer and similar coatings for various uses, it is of the greatest importance that a degree of certainty should be attached to its durability and resistance to such elements with which it may come in contact. Any attempt at controlling laboratory tests will make for uniformity in production. The time element for outdoor panel test exposures must be hastened on these various experimental batches if the durability and various resistances wish to be known. Since lacquers and synthetic enamel coatings are relatively long-lived, mechanical reproductions of weathering influences are necessary.

Artificial weathering is produced in a machine known as the Weather-O-Meter and has become the accepted standard of industry and scientific laboratories for accelerated reproduction, study and

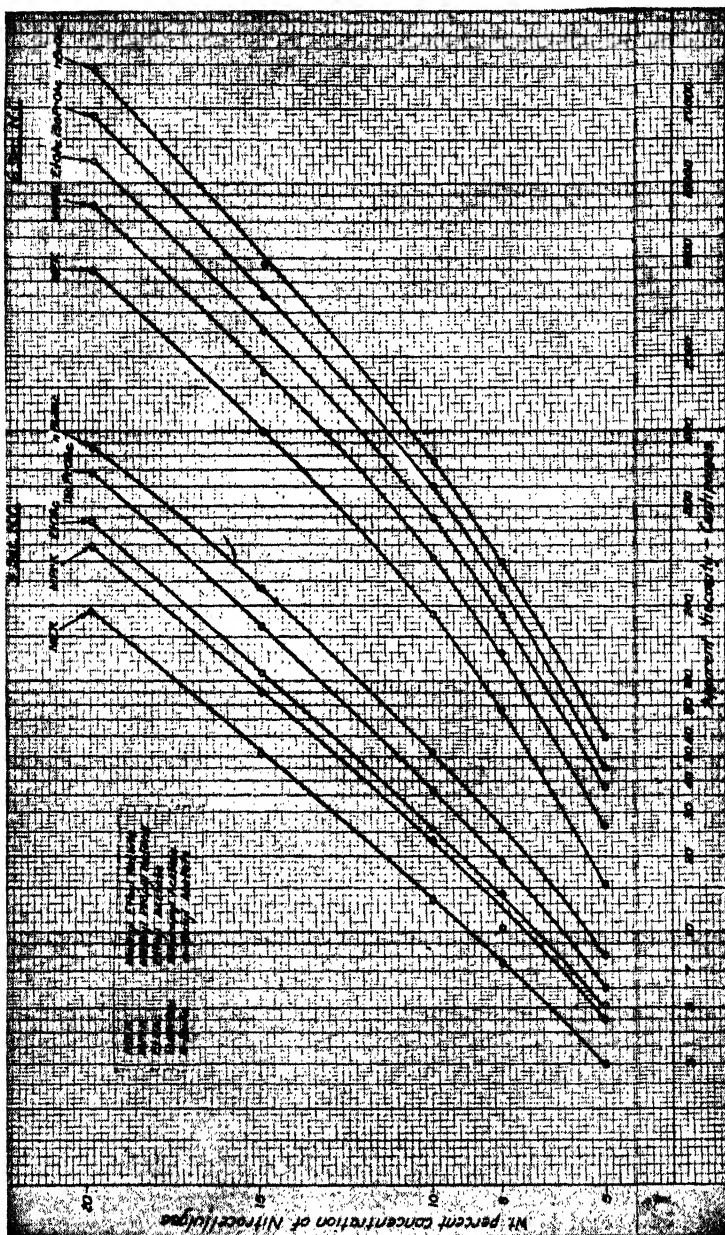


FIG. 67. Viscosity curves

measure of the sun, the reactions of rain, washing, cold, and heat in their relation to protective coatings. Weathering, in its association with climatic effects, represents drastic conditions of service. The combination of light and moisture is the most destructive agency in the deterioration of lacquer and similar protective coatings. Ac-

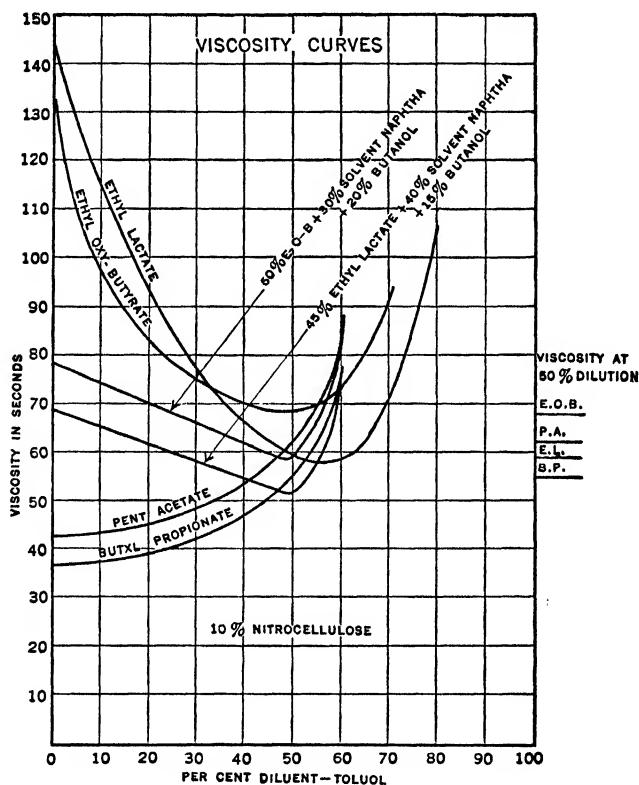
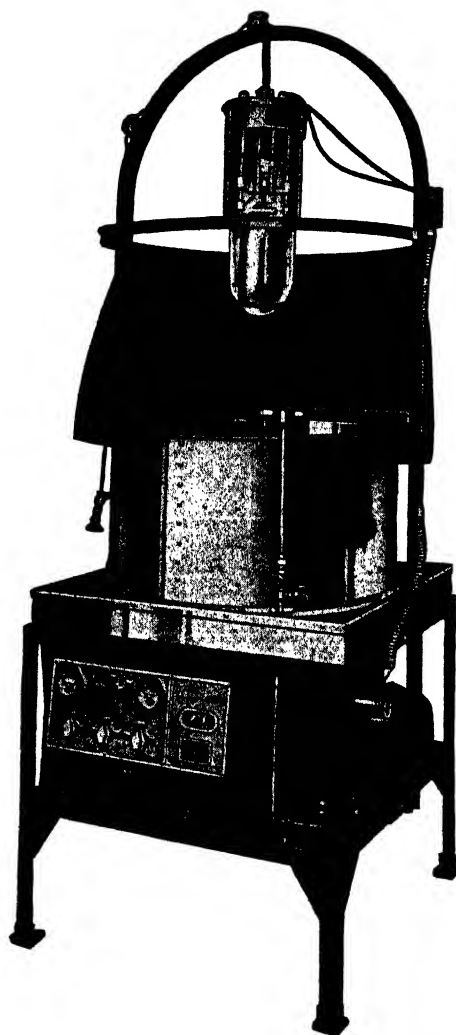


FIG. 68. Viscosity curves

celerated weathering measures such physical properties of given coating films and in so measuring, interprets such results as indicative of durability as may be associated with film protection placed in service.

The Weather-O-Meter consists of a chamber fitted with an arc as the light source. The light is suspended in the center of the chamber, and the source of light is produced through a violet carbon arc,

which is the nearest approach to direct sunlight. Inside this chamber is a rotating cylinder on which is placed the panels arranged in tiers



*Atlas Elec. Devices*

FIG. 69. Weatherometer

for exposure. Moisture control is maintained through a stationary outlet either at the side or a rotating cylinder located at the bottom of the chamber. (See illustration No. 69.)

Light, moisture, and temperature control are responsible for the aging, deterioration, and final breakdown of the exposed film.

The moisture as produced in the form of rain is of two kinds: the mild rain or spray which is shielded from the light and moistens the panels under exposure  $1\frac{1}{2}$  minutes in every 20, and the driving rain which is continued for 3 hours in the 24 hour cycle. In this, the lamp is elevated. The driving rain cools the panels and interior of the cylinder to a much lower temperature than during the 17 hour cycle.

The Weather-O-Meter operates for 24 hours a day and a standard exposure day is as follows:

|                                                           |          |
|-----------------------------------------------------------|----------|
| Carbon arc light and gentle spray .....                   | 17 hours |
| Vigorous water spray (about $100^{\circ}\text{F}$ ) ..... | 3 hours  |
| Refrigeration (about $-7^{\circ}\text{F}$ ) .....         | 1 hour   |
| Inspection of panels .....                                | 3 hours  |

The first day of exposure should constitute 17 hours of light alone without the mild spray. Succeeding days will then include the above schedule. A week of exposure to accelerated weathering is equal to 4 months' of outdoor exposure.

Panels when exposed should constitute complete finishing schedules, e.g., primer, surfacer, and finishing materials. Panels should be coated on sides, edges, and back before cabinet exposure. Wood panels of finishing lacquers or varnish are not exposed to the water spray test.

**REFRIGERATION** — After panels are exposed to the action of light, heat and moisture, they are subjected to the refrigeration cycle at  $-7^{\circ}\text{F}$  for a period of approximately 3 hours. It is common practice to subject the panels to this test directly from the heated cylinder without their remaining in the confines of room temperature. However, it is reasonable to believe that they should gain room temperature before the refrigeration cycle.

The author directs attention to a pamphlet of the New Jersey Zinc Company entitled, "Accelerated Weathering, its use for routine testing of paints."



### Outdoor Exposure Tests

In addition to the results as determined by an accelerated weather test, panels finished on production schedules are exposed to the direct action of the weather elements. Such panels are placed in an exposure rack at an angle 45 degrees facing southward and are examined at varying periods (depending on the nature of the coating under test). These exposure panels are examined for lustre,



FIG. 70. Exposure rack

*DuPont Co.*

durability, color change, chalkiness, checking, cracking, etc. These tests are counterchecked with the results of the machine test and results of retained standard panels. The failure of such exposures will vary with the time of exposure (season of the year). (See illustration No. 70.)

Revolving racks have been constructed to give quick weathering results. Such racks are arranged with swivel to turn in any direction laterally and with pivot arrangement so that the panels may always be perpendicular to the sun. This 90 degree angle exposure is said to lessen the time of exposure of certain finishes by one third.

## REFERENCE

- (13) American Cyanamid Company.
- (14) Laboratory manual — paint, varnish, and lacquer — Gardner.
- (15) Paramet Chemical Corporation.
- (16) American Cyanamid Company, dated April 1931.
- (17) This method is based on that of Eberstadt & Knoevenagel (*Z. für angew. Chemie*, vol. 1, page 505, August 29, 1914) and Knoevenagel (*Cellulose Chemie*, vol. 20, No. 9, 1922, page 119).
- (18) "Leaves from a paint research notebook," vol. J, October 1937 — New Jersey Zinc Company.
- (19) For further reference to work on this subject, attention is directed to the pamphlet, "Some physical properties of paint, varnish, and nitrocellulose films," Nelson & Rundle, New Jersey Zinc Company.

## FAULTS AND CORRECTIONS



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It is estimated that a large percentage of all lacquering and similar coating difficulties are directly attributed to the improper handling of the product and/or improper preparation of the surface on which the product is applied. It is imperative that the users of coatings observe the necessary precautions and thus have the assurance of exacting results at all times.

The particular characteristic fault found with a coating is usually magnified in the type of failure which it will produce. By knowing the various types of failures, one may easily arrive at the fault and, in knowing the fault, it may be corrected.

Some of the more common faults are given and certain corrections are offered:

### Adhesion

Paint and varnish materials cling to the work principally by adhesion, although they also have cohesive powers. Lacquers stick to the work mostly by cohesion, although they usually have adhesive power.

Adhesion is the theory of adhering to a given surface. While lacquer has adhesive power, it dries with a contraction which is caused by the evaporation of the volatile solvents, thus decreasing the original volume of material applied on the work.

Common causes of non-adhesion are often found in factors not influenced by coating materials, e.g., greasy surfaces or foreign

material on the surface. Such surfaces should be properly cleaned before coatings are applied.

### **Air Impurities and Air Line Troubles**

The mechanical application of protective coatings, which involve the use of a spray gun, necessitates compressed air to "break-up" or atomize the liquid which is deposited on the work in the form of a "mist." This compressed air, passing from the compressor directly to the gun through a water and oil separator or collection pot, may permit the passage of oil or water through the gun to the work. Spotty drying may result.

Care should be exercised to keep the "trap" well "bled" at all times as this will allow freedom of the line and insure oil or water from not reaching the wet finish.

Air impurity difficulties in the finishing room are corrected by maintaining adequate air circulation in the drying, finishing, and kiln rooms at all times. A flow-meter will indicate certain air line troubles.

### **Alcohol Watered**

The presence of water in alcohol (usually the result of condensation from the air) is the cause of such faults as grayness in furniture finishes. This condition is customarily found in low proof alcohol and in such instances, a higher proof alcohol may correct the condition.

### **Alligatoring**

This is a fault in furniture finishing where heavy coat applications are applied on unseasoned wood. Usually one coat is applied over another before the previous coating is dry or a less elastic material is applied over one of more elastic nature. When alligatoring is fine and incomplete, it is referred to as "checking." (See "checking" and "cracking" — this subject.)

A correction of this fault would indicate that thinner (less viscous) bodied applications should be applied on the work and by waiting sufficiently long between applied coatings.

## Baking

Lacquers based on nitrocellulose involving the ratio of six to eight parts of synthetic resin to one of nitrocellulose and applied over the customary primer and surfacer are "baked" (force dried) at 150°F–175°F, until sufficiently hard to be gasoline or water sanded to a smooth surface. They are then "rebaked" at 200°F (flowing out the sandpaper scratches) and a hard and glossy surface results. Such schedules will eliminate mist-coating and polishing. These basic nitrocellulose lacquers produce exacting results but should be scheduled in accordance with the manufacturer's instructions if desirable results are to be obtained.

Baking as an applied paint-like coating is understood to begin at 200°F, while force-drying is enacted between 150°F to 200°F. Lacquers may be force-dried while oil and synthetic enamels are usually baked.

Baking for too short or too long a period or at too high temperatures is often the seat of many finishing troubles.

## Balanced Solvents

Thinners or reducers composed of varying proportions of solvents for gum-resins, nitrocellulose, etc., in accordance with the lacquer it is to reduce, is often less expensive and causes little, if any, finishing trouble.

A manufacturer's recommendation of thinner-reducer to be used with a given lacquer will invariably give satisfactory results. No two manufacturers have exactly the same composition of product. There is no universal thinner-reducer applicable to reduction of all lacquer products. Thinner-reducers are nitrocellulose lacquer dispersing agents and unless balanced ratios of ester to hydrocarbon to alcohol is present, precipitation or flocculation will result.

## Bleeding

In wood finishing practices, this fault is usually referred to in connection with stain or filler; either the improper type being used or succeeding coating applications are applied before the stain or filler is thoroughly dry. In furniture finishing, a light color applied

over stained wood is the source of considerable trouble. Thin coats of shellac washed with weak solutions of sal-soda will often overcome the trouble. If followed by white or light tints, two coats are recommended, the first coat being applied in a thin manner. Aluminum coatings or casein water solutions with traces of aqua ammonia are often recommended.

Certain solid covering pigments are said to "bleed" when other coatings are applied over them and show the first color. Chief among these color offenders are the reds. Non-bleeding red pigments are now available which will accept applications of white lacquers directly over the surface without showing a "bleed." Blue dye matter added to the less intense carbon blacks will also "bleed" if a white stripe is applied. High color carbon blacks which do not "bleed" are recommended.

### **Blistering and Bubbling**

This fault is often present in toy finishing technique where the objects are placed on prepared racks, immersed in dip tanks and hung near the ceiling for drying. The poor air circulation at this point is responsible for this condition.

It may also be attributed to dipping a wooden object too soon after agitation of the liquid coating, thereby depositing air bubbles which are forced into the liquid coating by violent agitation and thence onto the work.

Blistering or bubbling frequently occurs near the edges, sharp corners or at the base of wood turnings where the lacquer or similar material is heavily deposited. This is probably due to the edges, corners, etc., being a natural flow point in dipping or a likely place of continual spray deposits.

This finishing fault may be traced to unbalanced solvents in the structure of the lacquer or by insufficient reduction of the lacquer. Improper atomization (spray) or application has a great bearing on this finishing fault. It is very often caused by too much heat being present. See "Baking" under this subject for time and temperature handlings.

### Blooming

This fault or condition should not be confused with blushing, although they are similar in appearance, their causes are entirely of a different nature.

Blushing of lacquer films occurs while the film is wet, while blooming appears after the film is supposedly dry; although the film is not thoroughly dried and hard. Blooming is the result of rubbing too soon after finishing or the use of too coarse a rubbing abrasive or too hard a rubbing action.

The best manner of correction for this condition is, of course, to be certain the surface is dry and hard before an attempt is made to rub the film.

A bloomed surface may be cleaned by washing with soap (free of alkali) and warm water, followed lightly with rottenstone and polished with chamois skin.

### Blushing

"Blushing," "clouding," or "white trouble" is the appearance of a cast or cloud over a film of applied lacquer, which renders it dull and lifeless. It is directly attributed to high humidity in the atmosphere; this high humidity is present in greater proportions during the summer months when the atmosphere is heavy and the weather humid. The moisture content on humid days is about seven times that of winter days. This condition may also be caused by moisture being present in the spray line or by direct draught on the work before the lacquer film is dry.

The presence of moisture is fatal to a lacquer, unless some means are provided for its removal before the film sets. The removal of water is usually accomplished by the use of solvents which have lower vapor pressures than water, or the use of those solvents which form evaporating mixtures with water.

Blushing may likewise be caused by improper selection of solvents used in a particular lacquer. (See SOLVENTS, Part I, Chapter III, especially the subject of hygroscopicity. The ability of a solvent, or a group of liquids in which one or more is highly hygroscopic, to become highly miscible with water will influence a blush condition.)

Vaporization of solvents from a lacquer film and the proportioning

of these solvents so that the mixture will remain balanced during drying is very important. Solvents evaporate at their boiling points; as a matter of fact, neither the boiling points nor the vapor pressures can be taken as an index of how the solvents will evaporate from a lacquer film. This is particularly true of thinners (or mixtures of solvents). Many solvents at their boiling points form constant boiling mixtures and these give off a vapor which has a lower boiling point than the individual components. At room temperature many solvents form evaporation mixtures with evaporation characteristics different from the individual components. These properties of solvents make it possible to produce combinations which act in a lacquer in a manner quite different from what an inspection of boiling points or vapor pressure might indicate.

The white cast referred to as "blushing" is caused by the precipitation of the nitrocellulose (or other solids) in the wet film during the solvent evaporation (drying period). This precipitation is the result of the absorption of moisture in which the low boiling solvents as they evaporate from the lacquer film, cause a cooling of the surrounding air.

The following table shows the wet bulb or evaporation temperature of various common volatile solvents used in lacquer formulation. To avoid condensation of atmospheric moisture on lacquered surfaces, the dew point of the air must be below the evaporation temperature of the particular solvent:

| <i>Liquids</i>     | <i>Wet Bulb or<br/>Evaporative Temperature</i> |
|--------------------|------------------------------------------------|
| Water              | 50°F                                           |
| Acetone            | 30°F                                           |
| Ethyl acetate      | 35°F                                           |
| C.D. alcohol       | 40°F                                           |
| Benzene            | 48°F                                           |
| Toluene            | 56°F                                           |
| N-butyl acetate    | 65°F                                           |
| Butanol            | 66.5°F                                         |
| Butyl propionate   | 69°F                                           |
| Cellosolve         | 71°F                                           |
| Cellosolve acetate | 72°F                                           |
| Pentasol           | 72°F                                           |

[ Dry bulb temp. of air — 75°F ]



The various types of air are described as:

*Dry air*: which is air free of moisture. This type may be manufactured, and involves (1) temperature, (2) humidity, (3) purity, and (4) control of air movements.

*Saturated air*: which is any air containing moisture (saturated air is humid air, but humid air is not necessarily saturated air).

*Relative humidity*: which is the percentage of saturation or the difference between the weight of water in air by the weight it holds when saturated.

**HUMIDITY** — Air itself is a mechanical mixture, chiefly of the gases, oxygen, and nitrogen, and nearly always contains impurities as ammonia, carbon dioxide, and sulphuric acid.

Atmosphere has the property of retaining varying amounts of moisture in a vapor state. The maximum of water vapor held by a given space at a definite temperature remains unchanged. As the temperature is increased, the given space to retain vapor is likewise increased; conversely, as the temperature is lowered, this excess moisture is condensed. When condensation takes place, the atmosphere becomes saturated and when the temperature is further reduced, the air becomes supersaturated and the moisture is precipitated. When this point has been reached, the remaining moisture is equalized to the condition surrounding the newer temperature. The temperature at this stage, where the air is saturated, is referred to as the "dew point."

In lacquer finishing, the moisture mentioned above is occasioned by the cooling effect of the evaporating solvents which in turn coagulates the nitrocellulose.

A well-known fact is that the cooling of any humid atmosphere will cause a condensation of a part of its moisture. The evaporation of a liquid reduces the temperature at the point of evaporation. For example, pour ether or alcohol on the back of the hand and note the cooling effect upon evaporation.

The amounts of water vapor contained in the air is referred to as the "humidity" of the air. "Absolute humidity" is referred to as the number of grains of moisture in one cubic foot of air of the atmosphere. As the temperature is increased or raised, this increases very rapidly.

“Relative humidity” is an expression of the amount of moisture in the air in terms of proportion of the moisture present to the amount of moisture the air could hold at that given temperature. The relative humidity is lowered by heating air and raising it if it is cooled.

**HOW TO OVERCOME BLUSHING** — The spraying or drying room in which the lacquer is applied should be kept warm (70°F) in order to keep the relative humidity down and insure proper drying of underneath coatings. The spray line should also be checked to see that it is free of moisture. Thus the temperature and relative humidity of the room in which lacquer is used is important. Leveling of the film after spraying, evaporation of solvents from the sprayed film, softening action on undercoats, the tendency for blushing and such troubles are all influenced by conditions under which the lacquer is used.

**RETARDERS** — The use of sufficient and balanced ratio of high boiling solvents is advocated. These high boiling, slow evaporating liquids retard the evaporation of the lacquer volatiles so that the temperature of the metal or article on which the lacquer has been applied is not lowered as in the case where low boiling, fast evaporating liquids are employed. Butanol is effective as a blush preventative and likewise it is a water expeller. The retarder is often added to the lacquer and often a wet coat of reducer or reducer having a small amount of clear lacquer (for body) is applied over a blushed film.

Blushing troubles are less common today, and the synthetic resin in the average lacquer is partly responsible along with more properly balanced lacquer composition.

### Body-on-the-Work

Fullness is another expression often used for body-on-the-work. Deposit of material on a given surface may be directly allied with: How much solids at a spraying consistency. Naturally, in lacquer application, where heavy bodied materials are used with equal or better volumes of thinner, the film formation or “body-on-the-work” is less than materials that are used at spraying consistency.

The adoption of synthetic resins in lacquer formulation has pre-

mented greater solids in lacquers at "spraying consistency." Lower viscosity nitrocellulose with synthetic resins has increased the solid content of lacquers by an additional 15% over the solid content of a few years ago.

Synthetic varnishes for furniture finishing show an increase in "body-on-the-work" over the oil-resin varnishes of a few years ago.

### **Bottom Drying**

Such materials as varnish and synthetic enamels dry from the bottom up, whereas lacquers dry from the top downward. Bottom drying is less likely to show checking or cracking defects. This does not indicate that properly compounded lacquers, applied in a proper manner, and over properly treated surfaces show a greater tendency to produce a checking or cracking condition.

Lacquers may show a bottom-drying action if applied over an insufficiently dried paste wood filler in wood finishing or over a film of shellac which may have "case hardened" in the deep pores of the wood.

### **Bridging**

This film condition is usually present in the final coat application of the finishing schedule. Too heavy an application of the lacquer, too "fast" a thinner combination (either in the structure of the lacquer or in the reducer-thinner), or temperature conditions which may cause a top-drying action, will promote this trouble. Temperature hastens the drying action of the film and since lacquers dry by the evaporation process, this combination causes a "bridging" of the film.

Proper conditioning of the finishing room will eliminate this trouble, correction in application and/or correction of the thinner, if necessary.

### **Brightness and Brilliancy**

The clarity or fullness of a coating (as a thoroughly dried film) is referred to as brightness or brilliancy. A non-balanced solvent mixture will cause lack of brightness or brilliancy by depositing a haze on the surface. This expression is used mostly in conjunction with lacquer or synthetic enamels.

### **Brittleness**

If the fossil resin content of a coating is increased without regard for a proportional increase of other solids, brittleness will result. Well-balanced protective coating formulae are not brittle.

Certain lacquers, as example, lacquer sealers, are short-brittle in order to induce sanding characteristics. Large percentages of synthetic resins do not produce brittle films.

Brittleness of coatings may be corrected by the manufacturer of the coatings.

### **Burning**

The reference to "burning" a finish is indicated as rubbing a surface with an insufficient amount of lubricant on the rubbing pad. The heat so generated causes the material to stick to the rubbing pad. In rubbing motor-car surfaces, a condition described as "burning" is indicated as lack of adhesion, where the material leaves the surface on which it has been applied.

### **Caking**

When varnish films are rubbed, the varnish sticks to the pad and forms a cake. Additional rubbing and friction may mar the surface unless the caking is removed.

Sufficient amounts of lubricant should overcome this condition.

### **Case Hardening**

This is described as a hard top crust with a soft mushy underneath deposit. This condition may be associated with products of paint and varnish or the condition under which the product is used and may be responsible for checking, cracking, or alligating. The moisture or relative humidity of the atmosphere or the drying conditions surrounding the work may correct the condition.

### **Chalkiness**

The film fault termed "chalkiness" is a surface condition described as "having been coated with a chalky layer." Chalkiness is present mostly in white finishes; titanium dioxide appears to be a lesser

offender than titanated lithopone. Basic earthen pigments are more susceptible than the chemical colors.

Proper selection of pigments will tend to correct this condition which is a matter for the manufacturer of the enamel.

### **Cheap Finishes**

Cheap finishes are often the source of many finishing troubles. Products are not carefully compounded for quality, therefore adulterants, etc., are likely to result in many of the myriads of finishing difficulties. See **BALANCED SOLVENTS** also **ORANGE PEEL**.

Use finishes of a composition that will indicate exacting results.

### **Checking and Cracking**

Checks and cracks in coating films are referred to as: "hairlines," "checks," "cracks," "alligatoring," "crazing," etc. When the fracture is in its first stage, it is usually referred to as "hairlines." In the more advanced stage, where the "hairlines" become larger, they are referred to as "checks," and as the checks become enlarged, the defect is referred to as "cracks."

Such film ruptures are caused by the moisture content of the wood, sudden or repeated temperature changes and other causes as follows:

**CROSS CHECKS (HAIRLINES)** — These are caused by a decided drop in temperature surrounding the coated object. These checks run at right angle to the grain of the wood, because wood expands and contracts across the grain and not with the grain of the wood. The nature of the checks will vary with the flexibility of the finish. The more flexible the coating film, the wider and deeper the checks or cracks will appear. The more brittle or less flexible, the closer the checks or cracks. These cracks or checks remain permanently visible.

Often a lacquer "amalgamator" is used on lacquer finishes in which the solvent is mostly amyl acetate. The amalgamator tends to blend the rupture together.

**HUMIDITY CHECKS** — A change in the moisture content of the wood will cause this defect. The swelling force of wood is sufficient to rupture the film which cracks with the run-of-the-grain. This film fracture remains as a permanent defect and the fracture is usually caused by the wood taking on moisture. When the cracks or checks

are closed and raised, they are generally caused by the wood giving off moisture (after finishing). In some respects this fault may be traced to the use of improper type of glue or the veneer being too dry which will readily absorb moisture.

Proper air, humidity, and temperature control will decrease the possibility of this trouble. Control of the moisture content of the wood before finishing is also suggested.

**PLASTICISER CRACKS (UNDERCOATER CRACKS)** — These are caused by the case-hardening of the lacquer film, the fault of which may be traced to the undercoat. The softer underneath film exerts pressure on the more brittle top surface and thereby fractures it. This type of crack resembles a hook or hairpin with one side broken. As the condition continues, the hook will join together.

Less plastic undercoats will correct this condition.

**OLD AGE CRACKS** — These are caused by the deterioration of the film and resemble "crow-foot" formations.

Cracked films, or film fractures termed by any of the above designations are, generally speaking, attributed to the wood absorbing moisture. The ruptures are the result of a strain. Such ruptures first appear in the form of "hairlines," increasing to "alligatoring." Flexible first-coaters and finish-coaters, between which is sandwiched "shorter" coating films, often overcome this defect in coating schedules. Generally speaking, each type of coating failure exhibits its own characteristic appearance, and such appearances will indicate the cause of the failure. See also **FURNITURE FINISHING, Part IV, Chapter XII.**

In metal finishes "cracking" is usually caused by the sandwiching of a soft coating or by too heavy an application.

## Circulation of Air

The thoroughness of circulating air throughout the wood storage has bearing on the rate at which moisture changes will take place in the wood, veneer, etc.

Wood should be stored so as to permit an adequate circulation of air, which will remove the excess moisture from the wood.

### Chipping

The chipping of a finish through ordinary handling may indicate a lack of elasticity or plasticity. The adhesion factor of such a coating to the underneath surface also influences this condition. Often shading strains are too heavily pigmented and tend to cause this trouble.

The cohesion factor of lacquers would ordinarily indicate that if the lacquer is proportionately balanced, such conditions will not occur.

### Close Drying

A material is said to be close drying when it does not show much fullness or body on the work. Often the true fullness is not brought out until after rubbing. This is especially true of wood lacquer finishes.

### Cloudiness

Cloudiness should not be confused with *blushing* but it is closely allied with *blooming*. Cloudiness is a condition referred to when a film is not clear and bright, but rather cloudy in appearance. It may be attributed to an improper type of thinner, which will leave a hazy appearance; a poor grade of sealer coat over the filler may also cause a cloudy appearance on the film. In the latter case, the lacquer applied over the poor sealer may penetrate through and dissolve the filler, causing cloudiness in the top lacquer film.

### Cohesion

This is the manner in which a lacquer is anchored to the work, whereby the film is tightly stretched over a surface. Factors influencing this action are found in a balanced and tested finish.

### Color Float

A color float fault may be attributed to the variance in specific gravity of one or more of the pigments used in a given enamel or by the improper dispersion of pigments.

Usually corrected by the manufacturer of the finish. See OFF-COLOR TROUBLES.

### **Compatibility**

All finishing materials are not intermixable with one another. For this reason, care should be exercised to determine the compatibility before mixing and thinning.

Always use thinners as recommended by the supplier of the coating to insure proper compatibility.

### **Consistency**

Allied with body or viscosity, the consistency for application is one of prime concern in the finishing industry. Improper consistency is often responsible for some of the many finishing faults.

Secure the proper intermixture (thinner and lacquer) from the supplier in consideration of surface application and air pressure.

### **Covering**

Lack of covering is usually referred to as the inability of a coating to hide completely a surface by spray application. A common fault when an attempt is made to cover dark undercoats with light colored enamels in one application.

Advocate the use of a corresponding light colored undercoat where the finishing enamel is of a fixed shade. In the instance of certain iron blue pigments and especially maroons, a corresponding ground coat is advocated (carbon black is frequently used). The pigmentation of the average lacquer should result in solid coverage.

Certain synthetic enamels (reds, blues, and blacks) will indicate, after being sprayed, that they may show insufficient coverage, but after flowing of the synthetic has progressed, solid coverage is indicated.

### **Crawling**

The refusal of a finishing material to remain uniformly spread is defined as crawling.

This may be influenced by the presence of a foreign material on the surface, e.g., grease, wax, etc.

### **Crazing**

The fault termed "crazing" is described as the appearance of minute ruptures or cracks of an interlacing nature on a film surface.



In the finishing of furniture, which may involve sudden changes to extreme cold, e.g., shipment during frigid weather, may be responsible for this fault. The use of brittle finishes of unbalanced nature which will not expand and contract may also be responsible.

If this is the instance, use flexible first coaters and finish coaters and shorter finishes between these films.

### **Dirt on Work**

It is essential that the matter of proper finishing room ventilation be considered. Lacquer finishes, which dry rapidly by the evaporation process, are less subjected to collecting dust than varnishes or synthetic enamels. Open windows and draughts may carry dust which may be deposited on a drying film, causing roughened surfaces and in some instances, where the deposit of dirt is slight, may cause grief in the rubbing operation. Finger marks on finishes may present a spotty drying from the oily exudation of the hands. Unclean spray booths are a natural collection point for dirt which may be deposited on a drying film.

### **Dry Spray**

This term is used in connection with the general application of finishes and is referred to and identified by a sandy-like appearance on a finished surface. This is caused by "overspray" of the finish, which strikes a surface for which it is not intended, and may also be caused by an insufficient reduction in spraying.

Dry spray is corrected by (1) correction in the air pressure, (2) correction in the reduction of the liquid, and/or (3) method of screening the parts that are subjected to the overspray.

### **Drying of Lacquer Films**

Lacquers dry by the evaporation of volatile solvents which are present in the wet film. In the application of lacquers, the transformation of a liquid layer to a thin and continuous "film" takes place. A solidification of the non-volatiles remains after the evaporation has been completed, which results in this continuous "film" of rigid nature that will resist the elements.

The use of synthetic resins with or without nitrocellulose has

indicated that such structural lacquers dry both by physical and chemical reactions.

The vapor pressure of an individual solvent or combination of solvents has great bearing on the drying of lacquer films. (At any definite temperature a liquid, due to its volatility, exerts a pressure called its vapor pressure.) Ethyl acetate, which has a relatively high vapor pressure is expanded quite readily from a lacquer film. The technology of lacquers has indicated that whenever ethyl acetate is used, a combination of higher boiling solvents are necessary to retard the expansion of these vapors. Such combinations then create a retarded vapor pressure which will result in an even film distribution of continuous nature that is free of orange peel or unevenness.

The addition of resin solution, flattening agent (in the form of a paste), or similar non-volatile structures further retards the drying of lacquer films. In this instance and aside from the volatile's vapor pressure, there is to consider the diffusion with other film formation by solidification. As the volatiles evaporate, the resistance of the film formation is increased and the diffusion is decreased.

Drying conditions immediately surrounding a wet lacquer film have bearing on the drying of that film. In like manner, the thickness of lacquer films is related to its formation and permeability over a period of time. Lacquers should be applied in thin films.

### **Dust in Pores**

A common fault in furniture finishing practice is directly attributed to not thoroughly removing the fine dust accumulated through sanding. These fine dust particles will absorb moisture from the air or from the stain (if water stain is used) and will not permit a good filled job. Fine dust particles present on the surface may cause the film to shrink.

Be certain the work is free of dust before the finishing materials are applied.

### **Filler Troubles**

**IMPROPER FILLER** — A satisfactory foundation is one of the fundamentals of good work. In order to secure desirable results in wood finishing, it is essential that the wood pores are properly filled, also

that a well-balanced (formulated) paste wood filler is employed. The paste wood filler should be properly reduced with a suitable thinner-reducer and applied over a proper surface. Soft pigments in fillers should be avoided as they may cause film shrinkage; also avoid the addition of oils which may produce non-drying films.

**UNDRIED FILLER** — The filler should be allowed to dry properly before any coatings are applied, as this will prevent shrinkage of the finish. Proper air ventilation and circulation is essential to securing a thoroughly dried filler. Avoid stacking the pieces of freshly filled furniture too closely.

**GRAYNESS** — Finish being oil rubbed too soon after application is one of the causes of grayness. Add more color to the filler and increase the drying time. If water is used in the staining operation, soft water should be used. All of these are likely to cause grayness — a filler trouble.

### **Flexibility**

The average lacquer is considered flexible to a sufficient degree to prompt necessary expansion and contraction of the film. Plasticiser and synthetic resins influence flexibility, but should only be added in proper proportions. If the gloss is increased through the addition of fossil gum-resins, flexibility will be sacrificed.

### **Gas Discoloration**

This is a common fault found in white refrigerator finishes and is often due to the escape of the refrigerant.

By a careful selection of non-volatile ingredients, this fault may be corrected.

### **Gasoline Discoloration**

As a general rule, lacquer finishes are resistant to gasoline. Certain improperly "cured" synthetic enamels may be softened and stained by gasoline.

### **Gas in Pigmented Lacquers**

This condition is often noted in long storage of pigmented lacquers. Nitrogen oxide fumes are sometimes detected and may be an indication of instability of the nitrocellulose or more likely the influence

of other unstable compounds on the nitrocellulose. A stabilizer is frequently used.

### **Gelling of Bronzing Lacquers**

Bogin, Kelly, and Maroney (21) indicate that among other materials, percentages of organic acids have a retarding action on gelation.

Bronzing lacquers of today are considered stable and little difficulty is encountered in gelling.

### **Glossing Up**

An expression which described a flat or dull rubbed surface taking on a gloss due to handling, etc. Pigmented flat lacquers show a greater tendency to "glossing up" than wax type of flat lacquers.

### **Goose Flesh Surfaces**

This is described as the condition of a surface having small slightly raised circular elevations. This uneven condition may be due to air pressure being too great or the thinner-reducer being of an improper solvent structure for reducing the liquid.

Check both the air pressure and thinner to determine the cause.

### **Grain Raising**

Water, which is usually present in water stains, is responsible for grain raising in the furniture industry. The application of a sealer coat which stiffens the raised fibres is common practice; these raised fibres may then be "cut" with sandpaper. The use of solvent non-grain-raising-stains will overcome "grain raising."

### **Gray in the Pores**

This fault is usually traced to a paste wood filler which has not been thoroughly dried. (See FILLER TROUBLES and GRAYNESS AFTER RUBBING.) The use of too coarse pumice stone in the rubbing operation leaves a gray deposit. Grayness attributed to filler troubles is underneath while grayness after rubbing is on the surface.

### **Hairlining**

Lacquers and varnishes which are subject to sudden and severe temperature changes will produce very fine lines or surface checks

which are referred to as hairline checks. Normally varnishes and lacquers are compounded so as to withstand normal temperature changes, but when sudden and severe conditions are presented, film ruptures will occur.

As a means of correcting this fault, it is suggested that the films be suitably protected with flannel or newspaper covering, (especially in warehouse and during shipment).

### Hardness

The hardness of an applied film is associated with its ability to resist abrasion. Lacquers should be "hard" yet have a degree of expansion and contraction that is consistent with the surface on which it is applied. Excessive amounts of gum-resins are responsible for hard "brittle" films which tend to produce a flaking action through abrasion.

Lacquers that are too hard are very brittle and of a relatively high gloss. Properly compounded lacquers are hard, but are not brittle.

### Heaving

This fault is due to too rapid an application of liquid coatings, and is a condition whereby the liquid of an applied coating penetrates into a previous coating and produces an uneven, ridge-like surface.

Sufficient time should be allotted between applications to permit the solvent to evaporate thoroughly from the previous coating. Certain establishments use a force-drying system while others resort to a sufficient air-drying system.

An uneven distribution of the moisture content of the wood or an elevation of the grain of the wood will also cause heaving.

If the moisture content is properly controlled in the kiln dry stage or if in the instance of plywood, care is taken in the moisture introduced through the glue used, by pre-drying in controlled temperature room to the proper moisture content, heaving will not result. The matter of too great an air-pressure may be corrected by lowering it, and the feature of "dynamiting" a finishing schedule may be corrected by allowing a longer drying period before further applications of the finish.

## Hiding Power

Applications of opaque enamels that have been reduced to a very thin consistency or that have been applied too lightly present an uneven film, with respect to covering or hiding.

Use less reduction (but sufficient to atomize properly at spraying pressure) or use more care in lapping the previous coat to insure better hiding.

## Holidays

Unevenly covered surfaces wherein previous or underneath coatings show through an applied film are referred to as "holidays."

Use more care in the application so that an even continuity of film coverage is enacted.

## Improper Cleaning

Cleaning operations in the metal industry were long regarded as being of minor importance and thus received the scant attention accorded a "necessary evil." Scientific investigation of cleaning processes have become essential steps in production schedules. Lacquer cleaning solvents, caustic solution, soap compounds and many patented cleaning solutions have made their appearance, and to a wide degree have met with favor. Rustproofing by hot solutions also meets with great favor. Experience and scientific study have likewise dictated constructive materials for handling corrosive agents.

Metal surfaces must be cleaned chemically and free of pinholes through which corrosion may take place. Oxygen is probably the most active corroding agent, and unless it is excluded from a metal surface, through protective coating applications, corrosion and rust will take place.

**RUST-CORROSION** — The producing and accompanying chemicals of rust are the most serious of indirect coating failures. The presence of moisture or water is essential to the process of corrosion or the formation of rust, but corrosion will not take place unless oxygen is present. Unless solution takes place, there is no medium in which corrosion can occur. Iron in its purest form has a solubility in water, but will not corrode in pure water if all oxygen has been removed and excluded.

Certain salts and acids act toward metals and cause little or no oxidation. Rust in itself is not considered harmful as similar substances find an outlet in lacquer and paint type undercoats. It is the accompanying chemicals that are most serious, and unless they are removed or destroyed, will work underneath coating materials and continue their destructive cycles.

Serious consideration should be devoted to thorough cleaning of metal to insure absolute freeness of all foreign matter before coating applications. A coating which will render metal surfaces passive under conditions which tend toward corrosion, and at the same time accept protective undercoatings and succeeding applications of enamels, would appear to be a satisfactory solution to this problem.

Such a cleaner should remove oil, grease, rust, and alkalies, and produce a surface to which paint or lacquer undercoats and enamels will adhere.

Phosphates, which are insoluble in water and permanent in oxygen, have proven the basis for development and widespread use in practically all of the most satisfactory cleaners of metal or chemical type of mechanical deposits, as an impervious coating against the inhibition of rust.

**SANDBLASTING** — While metal surfaces do not appear to be porous, it has been repeatedly shown that there are pores which are likely to contain moisture. To eliminate this porous moisture containing condition, sandblasting is sometimes resorted to. Sandblasting provides a satisfactory bond or tooth for succeeding applications of coating materials, producing both a cleaning and a "bonding" action for coating applications. It is a hard beating with moisture absorbing materials and removes all harmful substances from the surface of the metal, particularly scale. The use of sandblasting equipment is limited to such metals of hard nature or of a necessary thickness to withstand this beating action; the weaker metals may buckle through the excessive force used in the etching of the surface.

Sandblasting units in use are: sandblasting rooms, tables, mills, cabinets and tanks, the former having the wider application. The sandblasting room is provided with a perforated floor and the operator remains in the room during the operation, directing the nozzle onto the work. Operators are equipped with helmets as a protection from

abrasives and dust; the room being equipped with a dust arrester by means of a suction fan.

### Improper Ventilation

An improperly ventilated finishing room affects both the finish and the finisher. Proper ventilation is essential to the drying of the finish while proper expulsion of fumes is important to the working conditions and the finisher.

It is always considered good practice to place freshly coated work in a location whereby a free circulation of air is present.

### Kicking Up

See HEAVING. Kicking up is usually referred to in connection with applied varnish and sometimes to wood fillers.

### Lacquer over Other Finishes or with Other Finishes

Lacquer should *not* be used over questionable surfaces or over other finishes. When applied over aged varnish films, the conditions surrounding its durability are very much of a question. The type of varnish, baking period, or period of drying and date of application should be determined. If such information is not available, preliminary tests will indicate the next course of procedure; in any event, a tack rag may be passed lightly over the entire surface, which will insure a surface free of dust, dirt, etc., and, if the surface will accept lacquer, a thin application may be applied, followed by a heavier application when the first thin coat is thoroughly dried.

**SEALER COAT** — Thin applications of shellac, cut  $3\frac{1}{2}$  pounds per gallon are applied. Sufficient drying between coats is advocated and when the last coat of shellac is thoroughly dry, the lacquer applications may be applied. The first coat of lacquer should be applied very lightly — in a “dry” coat manner, yet must be wet enough to secure proper adhesion to the shellac coat. This is best performed by holding the spray-gun further away from the surface than in regular practice. The second and succeeding applications are applied in a “wetter” manner. The results, although apparently satisfying, are always questionable in view of the manner in which the surface was brought up to receive such finish coatings. Whenever motor-car



surfaces are involved, it is considered best practice to apply an oil type of undercoat. Baking of the surfacer is advocated and, if this is not practical, secure the manufacturer's recommendations with respect to the length of air-drying and whether it will accept lacquer coatings after drying.

It is an accepted fact that lacquers and allied products are structurally of a similar nature. The individual components of such products will vary with each manufacturer and, for this reason, it is always soundly advisable to secure all finishing materials that are to be applied on any given surface from the one manufacturer. This will most likely eliminate finishing difficulties, in view of the fact that particular paint or lacquer manufacturers can readily recommend products to be used in view of exacting requirements desired.

### Leveling

A properly balanced lacquer product or synthetic enamel should produce a satisfactory leveling or smoothness of the film.

Proper volatile (solvent) balance in consideration of the product should correct any tendency toward non-leveling. The use of improper thinner which is not in accord with the coating structure can be a disturbing factor. Too much air on a wet surface will likewise "set-up" the film too rapidly and thereby retard a leveling action to the point of "orange peeling."

### Lifting

Lacquers in drying by cohesive forces, tend to penetrate into previously applied coatings for adherence. Lifting, if it is present in this respect, will occur when applied over soft coatings (top or underneath). In other words, the film is not sufficiently dry to receive further lacquer coatings.

Properly dried (baked) films do not present this condition, and, in the instance of lacquers, a careful selection of solvents which will show less tendency toward exerting a lifting action is recommended. See subject of REQUIREMENTS, TYPES and FORMULATION, Part II Chapter VIII.

## **Livering**

Certain finishes tend to liver or show a bodying action, which is an excessive yield value. This condition is usually brought about as the liquid becomes aged.

This condition is referred to as a chemical reaction in which acidity has a certain responsibility.

Care in formulation and selection of proper ingredients to retard this condition should be exercised.

## **Loss of Flexibility**

This fault is usually applied to coatings which dry by oxidation, wherein such films, reaching a supersaturation point of absorbing oxygen, continue to absorb oxygen to a point of apparent disintegration. Lacquers do not lose flexibility of the film as a general rule.

Properly formulated lacquers are presented with a degree of expansion and contraction by the addition of permanent plasticisers and as mentioned, do not lose flexibility.

## **Milkiness**

See BLUSHING.

## **Moisture Changes**

This condition in wood finishing practice, has bearing on the shrinkage of lacquer films.

The veneer stock should be maintained at the same moisture content throughout the finishing operation as it may likely show through use.

## **Murky or Muddy Finishes**

This common fault is only present in furniture finishing, and is generally found in mahogany wood finishes.

Its remedy may be found in the filler operation. The mahogany woods are somewhat of a soft nature, and should water stains be used, it has been found to unduly soften the wood fibres and the paste wood filler in its admixture with the moisture present has been responsible for this murky or muddy finish. If after staining, the filler application is permitted to dry thoroughly before further

applications are applied, it has been found that this condition may be overcome. The staining operation may also be omitted.

### **Off Color Troubles**

This is a condition usually present in the automotive industry and on certain lacquer enamel colors. Lacquers will change in color appearance at certain age stages. For this reason, a wet film of lacquer as compared with a dried and aged film, will show a color variance. The specific gravity of certain pigments will vary so that pigments involved in a given combination to produce a specific color, tend to "float." Film thickness, air pressure and spraying consistency may also influence "off-color troubles"; mist coat applications likewise may influence off-color troubles.

Corrections may be brought about through the use of selective pigments.

### **Oil and Water in Lacquer or with Lacquer**

The presence of oil and/or water in a lacquer or on a surface on which lacquer is being applied, will result in a condition of spotty drying, or entire lack of drying throughout the surface, depending upon the amount of oil and/or water that is present. This condition may also cause peeling of a lacquer and a blush condition which in turn will cause graininess of the film of a clear coating.

Proper attention devoted to the oil and water separator attached to the spray line should correct this condition. See **SPRAY LINE TROUBLES**.

### **Orange Peel**

Orange peel or pebbling results from the application of a spraying lacquer or synthetic enamel in which the air pressure is either too high or too low for the size of the nozzle and consistency of the particular finishing material. It may result from an improperly reduced liquid (in view of the applied pressure and nozzle used), and also from too great a pressure in the presence of an improper thinner-reducer as a reducing medium. Even the proper spraying pressure with an unbalanced thinner-reducer will have a bearing on this condition. The distance that the spray gun is held from the

work is another cause of orange peeling and the application of chilled liquids on a warm surface or vice versa.

### **Overbaked Finishes**

Finishing materials as subjected to heat require definite time elements and temperature to enact suitable and satisfactory drying. The type of finish, time, and temperature facts should be obtained before the baking operation. Baking at higher temperatures or for longer periods than necessary will tend to change the color by "burning" and also produce brittle films.

### **Paint Remover Faults**

The nature of paint and varnish remover indicates the presence of a wax which top-seals the film and permits a strong solvent action in the form of softening by penetration. This wax deposit is a natural enemy of lacquers in all forms and wherever a paint and varnish remover has been used, be certain to follow the remover application with a thorough cleaning by lacquer cleaner to remove the waxy deposit.

Failure to do this will result in a spotty drying condition and loss in adhesion of the applied lacquer coating.

### **Pebbly Finishes**

The fault often referred to as a pebbly finish or effect is brought about through an improper amount of reduction at a given spraying pressure, whereby the coating is forced on the surface in dribbles or segments, rather than in a fine atomized form.

Reduce the coating to a greater extent, thereby permitting a proper atomization in an uninterrupted and level appearing film.

### **Peeling**

Failure to use suitable primer coating for the work in hand will cause peeling. In like manner, if a surface has not been properly cleaned to insure its freeness from grease and other foreign materials, peeling will result.

Use a good grade of metal primer of the type as advocated by the manufacturer of the coatings being used and make certain the "air-trap" on the spray line is "bled" frequently to insure freedom of

oil that may "seep" through from the air compressor. This oily residue may deposit itself onto or with the lacquer or similar coating being sprayed and cause the film to peel from the surface.

### **Permanence of Color**

This is a problem for the manufacturer of the particular coating rather than a fault of application. It is a known fact that certain colors are transparent, e.g., certain blues, reds, and maroons. For this reason, a ground coat is advocated.

Use select colors and always C.P. colors in protective and decorative finishing. Follow the manufacturer's instructions where any question of "ground coat" may arise.

### **Picking Up**

The selection of properly balanced solvent combinations will retard (and possibly correct) this condition. Be certain oil and synthetic undercoaters are properly baked before the application of lacquers.

Always apply a thin film first, followed by a wet cover-coat.

### **Piling**

This is the result of too heavy an application, or of holding the spray-gun too long a time in a given position, thereby building up the deposit. Also results from spraying too close to the surface.

Check into the atomization head of the spray-gun and investigate the air pressure, following the spray deposit with the movement of the hand holding the gun with the trigger open.

### **Pinholing**

This film fault is termed as the appearance of minute round holes in the film which have a characteristic appearance of a pin point.

These holes extend below the coating film and are most likely to make their appearance in the first few applications. When once they are present, they cannot easily be overcome by any additional coating applications.

In furniture finishing, wood having an improper moisture content which permits a partial closing of the wood pores when the filler has been applied, is responsible for this condition. A change in drying

conditions for the filler is responsible for opening the wood pores. When the finishing varnish or lacquer is applied, it cannot bridge the gap and pinholing results.

Use caution in the use and application of shellac, which, drying by the evaporation process to a hard film, is subjected to top fracture when the wood changes its moisture content, or when the wet application of finishing material strikes the top surface. Any captivated air that is present in the pores will cause pinholing, when it is liberated and escapes through the coated film.

### **Pitting**

This term is often used in conjunction with pinholing, although pitting is usually present in larger round holes which are very often confined to film surfaces and usually on sprayed varnish surfaces.

Oil, water or grease on the work may largely be responsible for pitting of the film surface.

### **Pockmarking**

This is usually the result of improper applications and is often referred to as orange peeling. Too heavy an application and/or excessive air pressure on an applied wet film will cause this condition.

Check the material reduction and air pressure for a proper spraying body which will correct this trouble.

### **Printing**

The fault known as printing as applied to varnish and lacquer films is the application of pressure to the coated film, either by finger imprinting, packing, etc. Lacquers dry rapidly and bind down tightly to the object on which they are applied; varnishes dry more slowly and do not bind down to the object as tightly as a lacquer finish.

Factors which may influence printing are: an improperly dried stain, filler or undercoat, or too heavy an application of the coating. A sufficient time should be allowed for drying before the coated object is packed, etc.

### **Puckering**

The wrinkling of synthetic enamels or a similar condition often referred to as crinkling and wrinkling is known as *puckering*.

The drier content of some oil base enamels or synthetics is often found to be too great and when subjected to heat causes a puckering action. Air-drying synthetics (about 6 to 12 hour dry type) when subjected to heat often show a puckering action.

A correction of the drier content may overcome this fault.

### **Raising of the Grain**

This condition is usually presented through the operation which involves the staining of the wood. Certain parts and types of wood which involve figuration through the medullary rays have a greater affinity to absorb moisture through water stains and therefore show an upheaval or raised action. Where water stain is used, lacquer sanding sealer and necessary sanding action tends to level the raised fibres.

The use of non-grain-raising-stain is advocated.

### **Reduction of Lacquer**

An improperly reduced lacquer will present an unevenly applied surface when sprayed and will produce a semi-stippled surface.

Lacquers require definite amounts of compatible thinners to disperse the solids and produce proper application. This should suffice and produce an even film continuity. The amount and types of reduction should be secured from the supplier of the particular lacquer being used.

### **Relative Humidity**

See BLUSHING.

### **Rubbing Through a Finish**

This condition will exist when an uneven surface is present. Such unevenness may be attributed to a raising in the surface due to an uneven moisture content of the wood. This uneven or wavy condition is furthered by the application of water stains or paste wood fillers. If the uneven condition is not corrected, the surface when coated will be ridged or uneven. As an attempt is made to rub this surface, the friction of the rubbing pad passing over the uneven or raised surface will rupture the finish by rubbing through.

Correct the source of trouble which in most cases is due to an uneven moisture content of the wood.

## **Rubbing Faults**

Varnished and lacquered furniture should be permitted to dry sufficiently before being rubbed. Such faults as "grayness" will be present if this caution is not observed.

Wait sufficiently long for the coated surface to dry thoroughly before rubbing and check into the manner of application whereby the rubbing action is not in too heavy a manner.

## **Sanding in the White — Sanding between Coats**

Sanding in the white is an important step in furniture finishing, the proper type of sandpaper should be used and the sanding is customarily executed lengthwise — with the run-of-the-grain.

Sanding between lacquered or varnished coatings is followed out and a well-lubricated paper should be used. Such operations are indicative of producing very satisfactory built-up and level films.

## **Scaling**

Inasmuch as lacquers dry mostly by cohesion, rather than by adhesion, such applied coatings knit together so completely that when evaporation has been completed, there results one heavy and continuous film. In the instance of varnish, however, two applied layers of the film may be singularly pried apart. In the rubbing operation of the latter, if the top layer is cut through, this condition is referred to as scaling.

Since scaling is likely to result from uneven drying of coatings, thereby permitting an improper degree of adhesion, it is suggested that the drying of such films be investigated and, if necessary, corrected to prevent scaling.

## **Seediness — Separation**

This is referred to as a settling out of one or more of the ingredients of the finishing material. This specky condition may be attributed to a chilling action or to the use of an improper thinner-reducer. In pigmented materials, separation of the pigment may be due to improper dispersion.

In correcting this fault, do not store finishing materials in extreme cold places. Investigate and secure the proper type of thinner-reducer for the coating at hand.



### **Shrinkage**

The shrinkage of an applied coating film is the disruption of the level plane of the surface and is usually accompanied by a loss of lustre and general "dying away" of the surface.

Shrinkage in wood finishing is the result of an underneath movement of the wood, or may be traced to a movement of undercoat materials which have been improperly dried. If this latter case is in a very severe state, checking and cracking will result. Changes in the moisture content of the wood are largely responsible for this fault.

### **Sinking In**

The application of coating materials over a porous surface will be responsible.

Since the condition is more pronounced in an underbaked undercoat, it is suggested that higher temperatures or longer time elements of baking be given in order to create a harder surface.

### **Skinning**

In varnishes and enamels, skinning is usually the action of exposing the material to the air or may be due to an excessive amount of driers. This may cause a specky surface in application. Skinning is not applicable to lacquers.

Seal the containers tightly and check the amount of drier used.

### **Soft Films**

This fault is usually applied to varnishes or synthetic enamels. Undercoats for use under lacquer should be baked sufficiently hard, otherwise sinking in or picking up will result.

### **Spotty Drying**

This condition is usually the result of grease, wax, etc., on the surface prior to the coating application.

Make certain the surface is clean to receive the application of decorative or protective coatings.

### **Spray Gun Troubles**

It is the best policy to follow directions as supplied with the spray gun for pressures, type of spray, etc.

## **Streaky Finishes**

An improper adjustment of the spray gun may largely be responsible for a streaky finish.

## **Striking In**

See SINKING IN.

## **Sweating**

This fault is usually found in varnishes when they become glossy after dull rubbing. This is caused by rubbing the varnish before it is thoroughly dry; too heavy an application or too much friction may cause a heating up of the film and thereby cause sweating.

## **Swelling or Lifting Action of Lacquers and/or Lacquer Solvents**

The application of a coating material over itself, e.g., lacquer over lacquer or varnish over varnish will increase in deposit, builds up a finish, and cover such defects as grain effects and leafiness of metal, etc. The use of lacquer over other finishes and/or with other finishes is described elsewhere.

Lacquers as applied over varnish films cause a swelling or lifting action of the varnish film by the solvent constituents of the lacquer. There are a few exceptions to this rule, e.g., age and type of varnish and whether the varnish has been baked or air-dried. As a rule, baked varnishes or enamels do not lift as readily as air-dried films.

It is apparent that the low boiling rapid evaporating solvents have a lesser lifting action on varnishes than the higher boiling, slower evaporating solvents which remain on the varnish (in a wet state) for prolonged periods. The alcohols and hydrocarbons are used to good advantage since they are not esters. In some respects a 3½ pound cut of shellac is used as a varnish sealer coat.

## **Tackiness**

While a varnish film is going through the drying stage, tackiness exists and retains a " tack " for some time — until it is practically dry. Lacquer does not exhibit a tacky stage.

### Thinners

The relation between lacquer troubles and lacquer thinners is one of the common faults of lacquers. Cheap thinners will not mix properly and therefore the flowing qualities are affected.

Balanced thinners with a proper proportion of ester, hydrocarbon and alcohol are necessary to secure satisfactory results.

### REFERENCE

- (21) *Ind. & Eng. Chem.*, vol. 23, 982-5 (1931).

## PART IV

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### CHAPTER XI

#### APPLICATIONS

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##### Spraying

The mechanical application of lacquer by the spray gun medium has been responsible to a large extent for its widespread use. This mechanical application permits a greater output and the maintenance of finishing always at the same rate of mass production. The application of lacquers, synthetic enamels, etc., by the spray gun has eliminated many of the hand labor operations that were involved in early motor car production; under the old method of applying undercoatings, color varnish, etc., a motor car job required around 200 hours, whereas by spray gun application, the job entails only about one tenth of that time. Spray gun application of lacquer is largely responsible for turning out cars "on the line" at the rate of one every two minutes.

The following equipment is necessary to satisfactorily apply lacquer, synthetic enamels, etc., by this method of application: COMPRESSOR . . . SPRAY GUN . . . HOSE.

Of this equipment, the SPRAY GUN is very important and an equally important requisite to good work is the selection of the proper type of nozzle opening. Spray guns should be selected which present (a) thoroughness of atomization; (b) control of spray of a uniform size and shape; (c) ease of operation, adjustment, and ability to clean; (d) fluid control and fluid cut-off. (See illustration No. 71.)

COMPRESSOR — An adequate supply of air free of oil and water is important and in order to attain this, a proper type of compressor

is necessary. In most spraying establishments, a compressor equipped with an automatic starting and stopping device at fixed pressure is used. When a certain amount of air has been used from the storage tank, the motor is automatically started and pressure is built up and maintained at all times. An automatic safety valve is located on the compressor which functions at a certain maintained compressor pressure. It is always a good policy to use a sufficient amount of air in spraying and the air pressure on the gun should always be kept at a minimum; excessive air creates overspray on the work.



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FIG. 71. Spray gun

**AIR REDUCING VALVE** — In building up air pressure in the compressor for use in atomizing the coating material at the spray gun, it is essential to have an air reducing valve to cut the high storage tank pressure to the desired amount at the nozzle. A gauge and valve may be located on the compressor or directly adjacent to the spray booth to determine the pressure. Usual spraying pressure ranges from 40 to 60 pounds on the gun, and often at this gun pressure, the air bank ranges from 80 to 125 pounds.

**OIL AND WATER SEPARATOR** — As both oil and water are arch enemies of lacquer, it is of utmost importance that they be freed from

the air. Considerable trouble is caused in the finishing room by oil and water being contaminated with sprayed lacquer. If the compressor is located outside a spray room, and if the air is passed through a pipe line into a heated room, moisture may condense and cause the pipe to sweat on the inside. Oil may enter the line from the compressor. For these reasons, spray equipment should be fitted with an oil and water separator or trap. Such a device permits the air to pass through excelsior or a similar filtering medium before passing through the hose and ultimately the gun. A petcock is located at the base of the separator for draining purposes. The separator should be "bled" frequently.

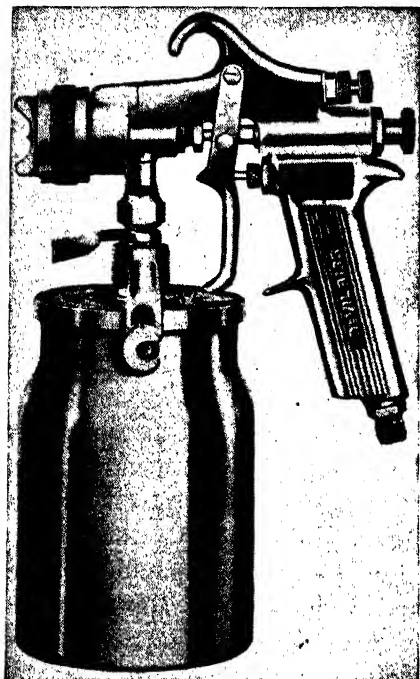
**HOSE** — A flexible hose fitted with threaded attachments is used. This composition rubber hosing is impervious to the action of lacquer and solvents which may pass through it. The hose should be cleaned after use and lacquer or similar coatings should not remain in it overnight. The following types of spraying units are used: **GRAVITY FEED . . . SUCTION FEED . . . PRESSURE FEED.**

**GRAVITY FEED** — The container with the material to be sprayed is placed in an elevated position. This container is suspended by a block and tackle and hoisted in place by hand. Equipment of this type is generally used in the furniture finishing industry and is especially adapted where materials of low viscosity are employed. The lacquer or varnish, after having been reduced to an applying consistency (if it is not received as such) is flowed to the spray gun by gravity. The air intake attachment on the spray gun atomizes the coating material, whence it is applied in the form of a mist. An air agitator attachment may be fitted on the container cover for air injection and agitation (when the drum is on the floor level). This is desirable if colored coatings are being sprayed. The air attachment may be extended directly from the air scrubber or separator. Some production establishments use the original drum shipping container which is elevated above the spray booth and spray directly from it. This is found to be satisfactory but air pressure should never be placed on such containers.

**SUCTION FEED** — The cup type, in which the material container is a part of the spray gun, is utilized for small work, and particularly where different colors are being used. In this type, the cup takes the

place of the fluid hose. Suction feed equipment is used for laboratory control work in the matching and control of plant production. Suction feed equipment will permit the application of heavier bodied materials and is often used in the logical application of such products as stipple and veiling lacquers.

(See illustration No. 72.)



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FIG. 72. Suction feed gun

**PRESSURE FEED** — This type of spraying unit is most generally used, especially in mass production. The pressure container is equipped with a clamped lid, pressure gauge, safety valve, relief valve, air and fluid cut-off valves, fluid outlet tube, and a pressure regulator which is used to vary the pressure on the material in the tank. Hand agitators or air driven agitators may be attached to the pressure pot and thereby will insure constant agitation of colored coatings. The viscosity of the liquid should be controlled; in other words, the lacquer, varnish or synthetic enamel must be of a spraying consistency. More than one gun may be attached to the

pressure pot and all may be used at the same time. Pressure feed arrangement meets with great favor in motor car production where more than one color may be employed in finishing. Generally speaking, the application of coatings from an air-tight container will permit the application of heavier bodied materials than the gravity feed type, although pressures will have to be regulated to fit such conditions as both viscosity, gun, and nozzle. (See illustrations Nos. 73-74-75.) Under this arrangement, coatings may be passed over a series of "fixed pipe lines," e.g., motor car coating application "on the line" and in this instance the coatings are prepared for spraying in

a separate unit and piped into the various lines. This system is known as the multiple pressure system.

**SPRAY BOOTH** — The spray booth should be strategically located with relation to the handling of production. Booths may be equipped with motor driven exhaust fans of the blower type by which, through created vacuum, the fumes and vapors are passed through an outlet chimney. Such booths have distributing plates between the exhaust

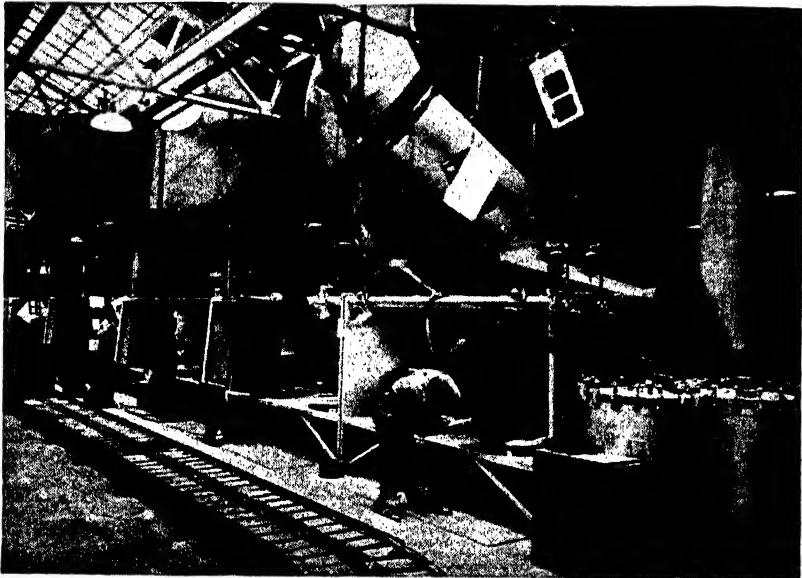


FIG. 78. Spray operations

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fan and the work being sprayed and have met with great favor. Vapor proof light reflectors and water or fire foam sprinkler devices are provided. The booth should be carefully cleaned at intervals; the inside of the booth is usually lined with strong paper securely attached to the booth. This paper is removed and burned as it becomes dirty. Some establishments use grease which is applied direct to the inside of the booth. Water soluble powder preparations have recently been introduced which are applied to the booth by spray gun applications and as the booth becomes dirty, the sides of the booth are washed by directing a stream of water on the surface. Hood arrangements are available for use in spraying motor cars, railway coaches, etc.





FIG. 74. Spray operations

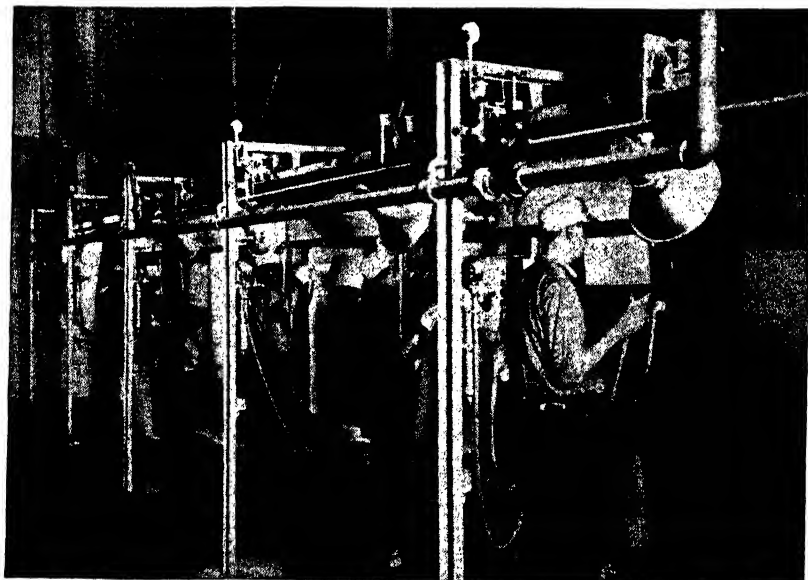
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FIG. 75. Spray operations

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**WATER WASH SPRAY BOOTHS** are a recent development and advancement in exhaust systems for finishing rooms. These booths which cleanse exhausted air by the air wash method, were developed to prevent the discharge of heavy solid lacquer and similar residues to the outside of the building. They make possible the operation of a booth in neighborhoods where standard fans or blower type booths would be prohibited, and in locations where a suitable stack could not be installed. They are especially recommended where the booth exhausts close to other buildings. They may be used when spraying any of the common materials, but they offer a particular advantage when such materials as primers and synthetic enamels are used where the residue is heavy and sticky.

A notable advantage of the water wash spray is the reduction of cleaning costs, both inside and outside the building. Frequent cleaning of fan, pipe, and stack is eliminated. Exterior appearance of the buildings requires less attention and lacquer or similar vapors do not work their way back into the plant to be caught in the fresh air intake filter.

Water wash spray booths are an investment which will repay their cost through savings in cleaning and maintenance, the elimination of neighborhood complaints, better working conditions, and the protection afforded by a clean finishing room and the reduced fire hazard. (See photographs Nos. 76 and 77.)

There are two types of water wash spray booths: the **NOZZLE TYPE** and the **CENTRIFUGAL TYPE**.



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FIG. 76. Water wash spray booth

**NOZZLE TYPE WATER WASH EXHAUST SYSTEM** — The nozzle type water wash spray booth was designed for the purpose of gathering and washing the lacquer laden air and the overspray from the spray guns and depositing the residue in a tank especially provided for this purpose. This system eliminates the possibility of any spray residue



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FIG. 77. Water wash spray booth

passing out through the exhaust piping and being deposited on nearby buildings or in restricted areas.

The unit consists of a spray booth with a watertight wash chamber made up of panels bolted or welded together, having a series of spray nozzles so arranged and directed that the air which is being exhausted from the booth must pass through the spray formed by these nozzles. (See illustration No. 78.)

A set of eliminators is imposed between the nozzles and the exhaust fan or blower, and these remove the heavier particles of water, returning them to the reservoir tank located underneath the water chamber. The exhausted air is in a high state of humidification and contains solvents in a gaseous form. Consequently, this air should

not be exhausted into the room, but outside the building through exhaust piping, as is the standard practice.

The resistance caused by the spray nozzles, the construction of the water chamber, and the use of eliminators require somewhat larger exhaust fans than are usually recommended with a standard direct type exhaust booth of the same size.



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FIG. 78. Water wash spray booth

Water is supplied to the spray nozzles by a direct connected motor-driven pump at a pressure of from 30 to 35 pounds at the pump. The inside of the wash chamber is completely saturated with a heavy spray from the nozzles, providing a complete wash of all metal in the chamber. Due to the loss of pressure by reason of the number of spray nozzles, the pressure at the nozzles is somewhat less than at the pump but never sufficiently so as to impair the efficiency of the system.

The eliminators are constructed in packs and are so placed in the water wash chamber that they are easily accessible through a door at

the end of the chamber. The packs are so designed that they can be easily disassembled, cleaned, and reassembled.

A threaded coupling is welded into the reservoir tank so that the city water line can be easily connected for quick filling and for washing down the tank.

**CENTRIFUGAL TYPE WATER WASH EXHAUST SYSTEM** — The centrifugal type of water wash spray booth serves the same purpose as the conventional nozzle type unit which employs a water pump with water nozzles, etc., that is, to wash the air and to prevent pigment from reaching the exhaust stack and outside of the building in which the unit is located. The principal thought in designing this unit was to eliminate the water pump and motors, piping, nozzles, etc., and to reduce the size of the water wash chamber. In reducing the size of the water wash chamber there has been accomplished the reduction of the sheet metal area exposed to the lacquer or similar atomized coating which passes through this chamber, thereby simplifying the cleaning of the interior. Due consideration is accorded the problem of the removal of the accumulated residue inside of this chamber. In many cases this is particularly difficult in that access to the chamber can be made only through the frontal opening of the booth, which means cessation of operation.

A feature of this new water booth is that the residue is carried away from the washing area and deposited on the surface of the water in the tank extension, permitting skimming at will without interference with production. The only requisite is that the water be compounded to the proper strength and kept at this strength by the periodical addition of compound. In this connection, compound should be added twice each day rather than daily. This does not mean additional expense because the ordinary daily portion can be divided in half.

It must be remembered in considering the conventional type of water wash spray booth that, while the residue is gathered as a floating mass on top of the water tank, there is a tendency toward precipitation of the heavier particles due to the water moving at a high rate of speed. This is reduced considerably with the centrifugal type water wash. In the conventional type of unit this precipitation eventually moves toward the pump suction and will build up in both the

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pump and nozzles, finally necessitating cleaning and replacement of parts, particularly when abrasive materials are used. The centrifugal type of water wash spray booth affords a longer period of time before the entire body of water has made a complete cycle through the water wash chamber. This slower movement of water permits the gathering of the residue in the open end of the tank and prohibits particles being carried back to the wash chamber as is the case with a faster moving body of water. The cycle of water change in this type of water wash is once every ten to fifteen minutes, dependent upon conditions of design and installation. The cycle of water change in the standard water wash is approximately once every two minutes.

Considerably less water is required to produce better results than those obtainable with other types of water wash booths. This is principally due to the design, which does not permit any by-passing or short-circuiting through open areas. By comparison, one gallon of water passing through the centrifugal type will do the work of four gallons in the conventional type and do it more thoroughly. Due to the nature of this design, the opening into the water chamber section is placed at a more appropriate location for exhausting the booth, and there is a direct passage of materials from the spray guns to the exhaust chamber.

The power equipment of the centrifugal type system is comparable to the nozzle type. The motors and two blowers are used but no water pump, thereby reducing upkeep expenses and avoiding frequent attention to the packing glands on the pump as well as frequent greasing of the bearings. Electrical wiring, necessary conduit, switches, and the eventual repairs to the pump unit have been reduced to a minimum.

**PRINCIPLES OF OPERATION** — The operation of this type of water wash is very similar to the conventional type, inasmuch as it is the purpose in both instances to have as much water as is possible contact the outgoing air. However, as mentioned above, considerably less water is required to produce equal results. The design of the centrifugal water wash is such that this exhaust air contacts more water, is more thoroughly washed as a result, and yet it consumes less water than a nozzle type booth.

The actual operating principle is very simple; the lacquer or enamel

laden air is exhausted from the spray booth and through a water curtain at the entrance to a smooth U-turn passage. The high velocity air passing through this washing passage is designed so that there are no open areas to permit short circuiting of the lacquer or similar laden air. In this way the water washes the air by impact and by folding or trapping it. A change in direction of both air and water results in further gathering of pigment. (See illustration No. 79.)

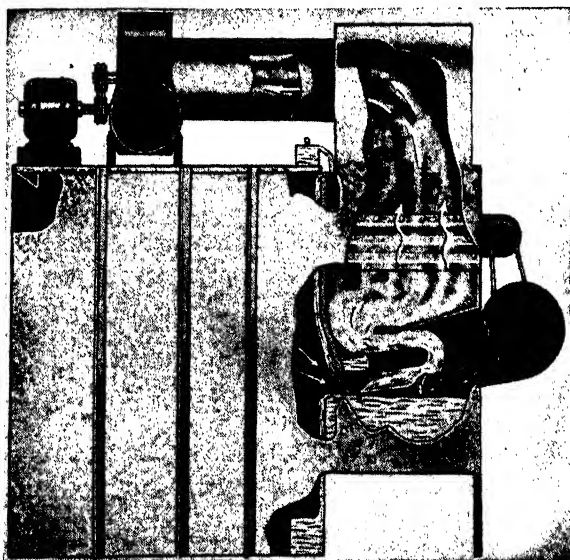


FIG. 79. Water wash spray booth *DeVilbiss Co.*

These pigments are gathered and deposited in a trough or sluiceway within the chamber, thus being immediately removed from the washing area. With this process the circulated water is removed before it is again used, which permits better gathering of pigments and affords a constant washing of the interior of the washing area. After serving these purposes, the water drops out of the air by gravity and a reduction of air velocity at this point permits it to flow out of the chamber into an extended portion of the tank for separation of the residue. The arrangement is such that the residue can be easily skimmed off for disposal. All water in the smaller globule and lighter atomized state is collected by a set of specially designed eliminator

plates and is also returned to the outside of chamber with that which is carrying away the residue.

The air removed by the exhaust fan, except for humidification, is free of water. It is too moist, however, to be returned to the room unless a dehumidifying means is employed.

Access to both the eliminators and the washing area is through a conveniently located door. Removal of a section of the interior washing passage, through this door, permits access to the entire interior of the chamber if necessary.

### Spraying Faults

- (1) When sags or runs appear on the work, the material flow valve on the gun should be corrected, or the gun should be held farther away from the spraying surface. The gun may be passed more rapidly over the surface or material may have been reduced too greatly for the air pressure being used.
- (2) When the spray is too light, the gun should be held closer to the work. The needle valve should also be adjusted and the gun tested for possible clogging.
- (3) When material is sprayed in spurts or spitting, the gun should be examined for possible clogging. The material may be insufficiently reduced. Spitting is usually attributed to air in the line. Check on the hose connections and pressure container for possible air leakage.
- (4) Poor atomization usually results in insufficient reduction of the coating liquid or too much material flow for the pressure on the gun.
- (5) To secure even coating applications, be certain to lap preceding coats.
- (6) In spraying clear wood lacquers, it is usually good policy to follow the wood grain, never zigzag. Spray directly across any surface before reversing the operation. Hold the gun at right angles to the work.
- (7) Always clean the gun after spraying.
- (8) The heavier the liquid, the greater the air pressure and the wider the nozzle opening necessary to get satisfactory results.



### Spraying Hints

- (1) Sand the work lightly between coats as this removes nibs and dirt.
- (2) By varying the applying pressure, correcting nozzle, etc., if necessary, brushing lacquers may be satisfactorily applied by spraying.
- (3) Use lower air pressure and wider nozzle spray for heavier pigmented coatings, e.g., surfacers, fillers, etc.
- (4) Control applying pressure when ground coats are used to prevent pebbling.
- (5) In applying stains use very low air pressure and small nozzle opening.
- (6) Always keep the line free of oil and water.
- (7) Apply a full wet coat of material on the work.
- (8) In order to secure best spraying results at all times, use the reducer that is recommended by the manufacturer of the material being used.
- (9) Spraying pressures found to be satisfactory are:
 

|                                |                 |
|--------------------------------|-----------------|
| Heavy bodied materials .....   | 10 to 20 pounds |
| Low viscosity lacquers .....   | 30 to 40 pounds |
| Clear furniture lacquers ..... | 50 to 75 pounds |
| Lacquer enamels .....          | 60 to 80 pounds |
| Synthetic enamels .....        | 60 to 80 pounds |
| Primer-surfacers .....         | 60 to 90 pounds |

### Applications by the Spray Method

These are too numerous to mention; among the common uses are: AIRCRAFT . . , ARCHITECTURAL . . . BRIDGES . . . FURNITURE . . . MOTOR CARS . . . METAL INDUSTRY . . . MACHINERY . . . MAINTENANCE . . . RAILWAY . . . ROAD TRAFFIC . . . SHIPS . . . REFRIGERATORS.

**THE TOUCH-UP SPRAY GUN** — Often motor car lacquered surfaces have become marred or scratched and such a rupture presents a very small surface to be repaired. Regular spray guns usually produce a spray about 6 inches wide which is more than sufficient to repair the scratch in the surface without depositing a heavy overspray. Touch-up "outfits" are available which include a touch-up gun, a special tray containing seven glass jars, necessary hose and connections. The jars

may be used for the lacquer represented by the various motor car body colors. This gun finds great use among the dealers of motor cars who are often confronted with a marred surface when unloading new cars received from the factory.

### **Floco or Flow-Coating System**

The application of lacquer or synthetic enamels by the Floco or Flow-coating process is carried on today to a very limited extent. The past attempts to use lacquers through this medium of application were with the object in mind of minimizing the waste through overspray as presented by spray gun applications.

The construction of lacquer enamels, presenting a coating of rapid drying nature, is considered too "fast-drying" for this method of application. As evaporation takes place, the film of lacquer thus formed is relatively "through working." The addition of extremely high boiling solvents to nitrocellulose bases is a near approach to varnishes, oil enamels, and japans; such materials are considered more suitable and better adapted to use by flow-coating. The cost of lacquer enamels with high boiling solvents is prohibitive.

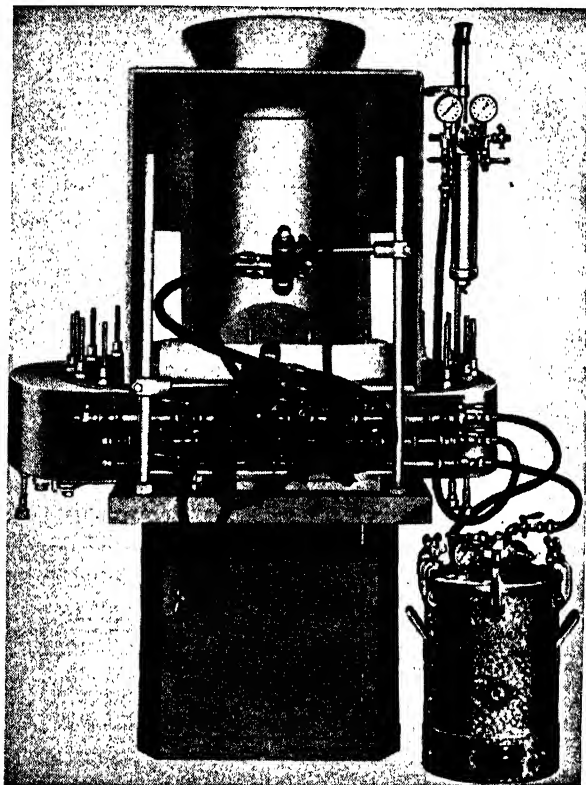
Flow-coating equipment consists of a material tank, rotary pump, motor, flow regulator, nozzle, fittings, hose, and trough.

Finishing materials are pumped from the bottom of the tank in a continuous stream through the hose to the nozzle. The material flow is adjusted by a regulator and the material that is not used at the nozzle is returned to the tank through the overflow pipe.

Flow-coating is best adapted in the motor car industry. Such parts which require coating, e.g., chassis or body, are placed on a draining trough which is fitted on a special rack. One end of the body is raised above and higher than the other end. The material is first applied along the top, then flowed over the upper half of the surface. This permits the application of sufficient material to insure a perfect flow to the bottom of the body. The excess material is collected in the trough which is centrally drained through a straining medium and returned to the material tank where it is used over again.

**Centrifuge** — This method of applying lacquer or synthetic enamel involves spray gun application and in some instances, automatic spray equipment. The instance of spray coating automobile wheels by this

principle would involve a turntable arrangement, upon which the wheels are secured. The spindle is set in a revolving motion and the lacquer or synthetic enamel is applied to the surface. Such coatings are handled by an operator who directs the actual applications to the



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FIG. 80. Rotary spray

surface. In such coating applications, the spray gun remains stationary while the surface to be coated is set in centrifugal motion.

Coating of steel barrels with lacquer or synthetic enamel is often performed with stationary equipment. Actual release of the coating from the gun is controlled by a mechanical arrangement. When a center band of a different color is necessary, a "block" is employed which protects the section already spray coated.

**Rotary Spray Finishing Machine** — A new and improved Rotary Spray Finishing Machine equipped with spindles, automatic spray gun, automatic control valve, hose, connections, etc., has recently been presented. (See illustration No. 80.)

Machines such as this are being used by industry wherever the product manufactured is such that it is adapted to automatic coating or finishing. A few of the many articles which are coated or finished by means of this equipment are: electric light bulbs, golf balls, bottles, jars, automobile parts, electric and radio parts, spools, novelties, telephone parts, ceramic ware, toys, and innumerable other small, lightweight articles.

Such a machine is capable of an approximate production up to 3600 finished, small, lightweight articles per hour. It is equipped with an improved speed reduction unit and may be operated at several different speeds. If desired it can be provided with a cam so that the spray gun operates at every other spindle when the machine is used for finishing larger articles.

Turntables will accommodate 15, 20, 25, 30, 40, and 50 spindles. The number of spindles is dependent upon the size of the pieces which are to be sprayed. Exhaust chamber is furnished and designed to meet the individual requirements and the machine may be equipped with a drying oven if desired.

**Planetary Crank Type Spray-Coating Machine** — Designed for automatically spraying flat or curved surfaces in sheet, roll, or panel form. The work to be sprayed is drawn through the machine by means of a conveyor. (See illustration No. 81.)

It is used for automatically spraying such products as hides, imitation leather, wall coverings, wall board, floor coverings, blackboards, paper, fabric, shingles, glass, tile, etc.

The production of this machine will range from 25 to 35 feet per minute, depending upon such variables as quality of finish, weight of coat, kind of material, setting of guns both as to location and adjustment of spray heads, and the width of the work. The maximum coverage of this machine, with two automatic spray guns, under average conditions, is approximately 240 square feet per minute. The proper operation of "fixed" spraying equipment is dependent upon

the consistency of the material, adjustment of the gun, and care of the equipment.

### Spraying High Solids Lacquer by the Heating Principle (22), (23)

The recent trend in coating has been toward the reduction of the number of coats of lacquer applied, while still maintaining the film thickness as previously obtained with a standard application of from

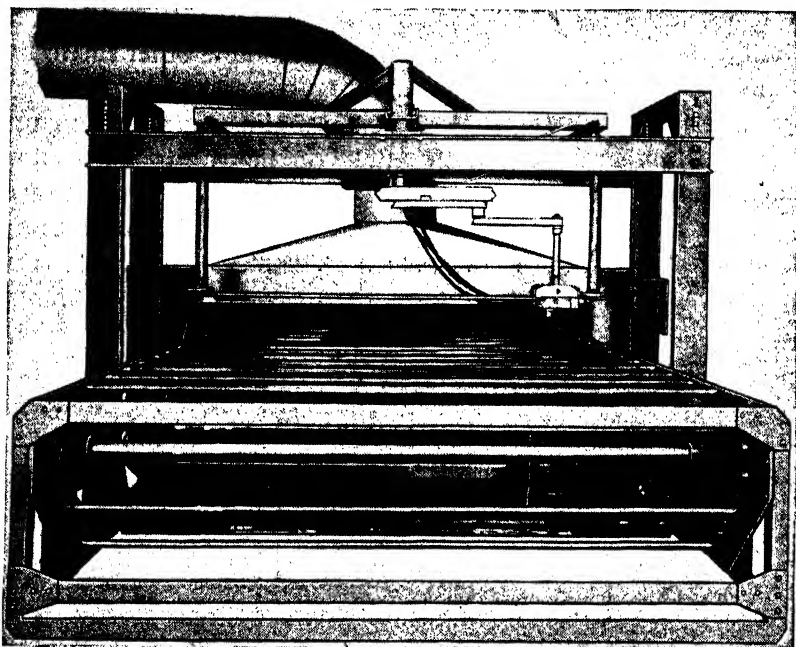


FIG. 81. Crank type spray machine

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three to five coats. This has been accomplished through the use of heated lacquers which require a special high grade solvent. The equipment is standard in some respects and special in others; regular spray guns are used, standard hose is used unless the lacquers are heated above 150° F — then a special composition hose is used.

There are two types of heating units recommended for this technique. One is a special type electric heater and the other is by an indirect means of heating (an oil bath surrounding the fluid coils is heated, and thus indirectly heats the material). This unit is elec-

trically heated with a thermostat control, and an additional feature of this heater is a coil which permits the fluid hose to be coiled up around the heater, so that the material in the hose will be kept heated when not in use. (See illustration No. 82.)

Placing the material container in a hot water bath, maintained to the desired temperature, is another method which can be used. The hot water bath can have its temperature maintained by a controlled jet of steam. This bath can be of such size as to permit the hose being conveniently placed in it when it is necessary and during the idle spray period, to keep the material in the hose heated.

### Brushing

The use of lacquers to be applied by brushing is limited. Brushing lacquers reached their peak during 1927 and since that period, they have been replaced by quick drying oil enamels and synthetic enamels. The problems of developing a brushing lacquer are many; for example, good brushing properties, proper hardness and toughness of the film, lifting of the previous coat, odor and stability in the shipping container are desired.

**SOLVENTS** — It would appear that each of the problems mentioned has bearing on the volatile solvent employed. While the range of available solvents for nitrocellulose lacquers is quite large, those that may satisfactorily be employed in brushing lacquers are limited. Best results are secured by using high boiling solvents which produce brushing properties and leveling of the film. In like manner, odor is quite important; solvents of the Glycol Ether Group have met with favor when employed (24).

**NITROCELLULOSE** — The lower viscosity nitrocellulose is most fre-



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FIG. 82. Heater lacquer unit

quently used (R-S  $\frac{1}{4}$  and  $\frac{1}{2}$  second types and minimum amounts of 4 second type; the A-S type is used which permits a greater percentage of the higher alcohols to be used in its structure). A happy medium of types and admixtures should be reached, as an increase in viscosity reduces the brushing properties.

**RESIN** — The type of resin employed will indicate the use to which the lacquer will be placed (whether interior or exterior). The commonly used fossil gum-resins are employed and while they are considered durable and tend to produce requisite hardness when introduced in proper proportions, the synthetic field offers greater possibilities. Ester gum is used mostly for interior work and the rezyls produce good results for both interior and exterior work.

**PLASTICISERS** — Dibutyl phthalate and tricresyl phosphate as well as castor and linseed oils are frequently used. Oregon Balsam of Fir, as plasticiser-blending agent and pigment grinding medium, meets with great favor, presenting smooth "pulling" under the brush and has the character of not lifting "old varnish" or first coat application of the brushing lacquer.

The usual caution is necessary in applying brushing lacquers. A surface clean and free of grease, wax, and such foreign substances is essential to good work. Always apply the lacquer with a full wet brush of material and it is good practice to begin a few inches away from and work toward a given point, meeting all laps by an overlap stroke of the brush. Brushing lacquers should not be "brushed" too much but rather flow it on and gently level it off.

## Dipping

Every surface that requires a lacquer coating cannot be dipped, but to such objects as toys, handles and wood turnings, pencils, baseball bats, golf clubs, bathroom fixtures and such, coatings by dipping have been found to be very economical.

A few years ago such objects were finish coated with oil stains and/or a very cheap paint, but today the quality and attractiveness of such a coated object has great bearing on its salability. In the case of toys, such manufacturers realize that the finish must last as long as the toy itself. Bright and permanent colors are used which retain their appearance over a long period of time. The finish must be

waterproof for sanitary reasons, and must be easily applied, especially from a mass production standpoint.

Clear and colored lacquers are universally used. These products should have the following characteristics: high lustre, solid coverage, tenacious film, rapid dry, and minimum freeness of drips.

The dipping method of applying lacquers is one of the first methods of applying protective and decorative coatings. Dipping lacquers are applicable to coating any surface (which may be of dipping size), although it is most generally used on wood and metal surfaces.

The two most generally used methods of dip coating are hand and machine dipping.

The hand method is used in small establishments where volume production is of secondary consideration and involves hand immersion of the object to be coated in the lacquer; withdrawing and placing on racks for drying.

The machine dip method will vary; some methods involve placing the objects (if small) in a spiked frame which will secure the object, immersing the frame by hand into the lacquer to cover the objects to be coated and withdrawing the frame by hydraulic pressure in a slow manner. The machine vibration on withdrawal should be controlled to a minimum. Another arrangement involves securing the objects on spiked frames which are inserted into a holding rack. The objects are then automatically immersed and withdrawn by a speed controlled machine. This type of machine is used to a large extent on production work. Such equipment is fitted with a number of dipping arms, each of which will submerge at different times in the working cycle. A machine of this type will allow as many as nine colors being dipped at the one operation.

**WOOD DIPPING** — A satisfactory finish may be obtained in one coat work on smooth non-porous woods, while porous surfaces usually require two coat work. The first coat application often involves a clear lacquer which is reduced to a greater extent than the finish coating (the finish coating is of color). This clear first coater stiffens the fibre and produces a firm foundation coat for the colored finish. The surface should be as smooth as possible if the best results are to be expected. If hand dipping, the lacquer should be of a thinner



(less viscous) body than a machine dip. Speed of withdrawal should approximate the rate of flow of the lacquer at that particular applied body. Hand dip applications should be controlled by the object to be dip coated and particularly by the projections it may contain. Machine dip which is usually controlled by slow speed of withdrawal involves a heavier bodied lacquer, although the machine may be controlled for fast immersion. The slow withdrawal with the heavier material will permit applying a maximum film thickness on an object with the least number of coating applications. The lacquer used is of the broom handle variety and of a very heavy consistency.

**METAL DIPPING** — The above holds true of metal dipping and the assurance of a surface free of grease and such foreign matter is vital to securing satisfactory finishes. The speed of withdrawal should be hastened in metal dipping and the lacquer should be reduced greater than in wood dipping technique. The reason for this is to prevent silking and undue surface defects in view of the smoothness of the surface as compared with wood, which is of a porous nature. The metal surface should be cleaned first with a lacquer cleaner; hand cleaning is resorted to if the size of the object will permit, or the object may be machine dipped into a liquid cleaner.

**DIP TANKS** — Dipping tanks are constructed of metal and are secured with tight fitting covers. These tanks are utilized for both hand and machine dipping; smaller tanks for the former method. The lacquer is placed into the tank and reduced with the proper thinner to a controlled dipping body, which is usually arrived at through hydrometer tests. After the thinner is added, sufficient time should be allowed to permit the air bubbles, which are forced into the solution by agitation of the thinner with the lacquer, to rise to the surface and break. This action is often hastened by blending or bleeding the air bubbles against the side of the tank with a cardboard or similar object. The cover should always be placed on the tank when not in use and the tank should be isolated from general activities because of fire hazards; but nevertheless with close proximity to production operations and facilities.

**HEAT AND BLUSHING** — It is often considered quite necessary to place the freshly dipped articles in a heated chamber to hasten the drying. This confined chamber should not be too hot but should be

warm enough to force the drying of the coating. A controlled drying chamber will thus eliminate "blushing" on the work.

**COATING OF OBJECTS BY USE OF THE DIPPING MACHINE** — Industrial establishments are often confronted with the problem of lacquer coating small manufactured objects. These objects are usually of such an odd size and variegated form that spray application cannot be considered. They are only coated for decorative purposes, since durability is not considered. A dipping machine is often resorted to and hand dipping is often employed. A walking-beam type of dipping machine, which is designed for the purpose of automatically dipping wooden, wire, and metal objects, has proven practical in many production establishments. This device is economical, having a capacity of from 25,000 to 100,000 small items per day. This depends on factors influenced by the construction of the object and the quality of the finish that is desired. This machine is used in the finishing of handles, pencils, shoe trees, etc. A rack holding the objects is inserted in the dipping arm and in turn is controlled by the walking beam arrangement which adjusts the dipping stroke. As many as ten different colors may be dipped at one application, or where a single color or clear may be involved, a larger tank containing such liquids is used. Tanks are provided at the base of each dipping arm; and the lacquer is first reduced to applying consistency. Heavy bodied lacquers are best suited for this method. The speed of withdrawal may be hastened and the heavy bodied material, through a slower rate of withdrawal, will deposit a heavier and more even coating, which will be free of sags. The machine requires little care and such care is only necessary for charging and discharging coated trays from the machine.

**MECHANICAL DIPPING** — The use of automatic dipping devices for coating smaller parts of industrial products has been exploited in recent years on a large scale, due to increasingly competitive conditions.

Automatic dipping devices are practical and employed on a quantity production basis in many establishments. They present the features of: (a) no skilled labor required, (b) no loss of time or material, and (c) volume production.

These dipping devices are constructed of steel, are rigid in con-

struction, and are operated by a vaporproof motor which is of controlled speed. The fume outlet is regulated by an exhaust fan in the roofing and thermostatically controlled fire smothering apparatus is provided.

Lacquer is placed in the container after first having been reduced to proper consistency. The lacquer is permitted to free itself of air bubbles (after reduction) which rise to the surface. Suitable rack arrangements are provided and are constructed in view of the object to receive the coating, and the racks are of a detachable nature. The racks are placed on the driving frame, which is set in motion on an endless chain and carried through the material tank at a constant speed. Racks may be previously loaded and delivered for dip coating by the conveyor system. The tank is located near the loading end of this conveyor and openings are provided at both ends of the tank, so that after the objects are coated, they pass at a slow controlled rate of speed through the machine and out at one end. The travel after leaving the tank is a series of upward and downward flights. This consummates sufficient time to insure thorough drying. Where dipping conditions require heat to force-dry the lacquer, steam pipe coils may be placed between the upward and downward flights or it may enter directly into baking tunnels (if synthetic enamels are involved).

**SQUEEGEE DIPPING** — The rubber gasket or squeegee method of dip coating broom handles is practiced. This involves hand application of the wooden handles in a confined chamber which is filled with lacquer; withdrawing the handle through a rubber gasket or disc which uniformly distributes the lacquer on the handles; the excess remains in the dip tank.

The dip tank is constructed of an iron pipe, 2 inches in diameter and of sufficient length to accommodate the handles to be dipped. A threaded cap is attached to the end which will allow cleaning the tank when a different color is to be used. This vertical pipe or tank is fitted with a  $\frac{3}{4}$  inch or 1 inch pipe attached horizontally about 4 inches from the top opening. A constant level tank or reservoir is attached to this pipe, which is of 1 or  $1\frac{1}{2}$  gallon capacity and allows the "overflow," through the space taken up by forcing the handle into the lacquer, to "back-up." This reservoir is fitted with cover to reduce the solvent evaporation.

This coating equipment is inserted into a hole in the floor so that the top of the dipping chamber is about level with the operator's ankles. A rubber gasket is secured over the top opening of the dip tank. Old automobile inner tubes are frequently used, although rubber washers of various hardnesses are often used. This gasket is laid over the iron lip and secured by nut and bolt between a plate fitting and the iron lip. The gasket is perforated with a round opening which is smaller than the diameter of the handle. The hardness of the gasket used has bearing on the thickness of the lacquer coating deposited and this thickness may be regulated by the consistency of the lacquer as well as the gasket opening.

The handles are immersed and withdrawn in a vertical manner and with a uniform rapid motion, and the pressure of the gasket must be uniform on all sides of the handle during withdrawal.

As the handles are withdrawn, the lacquer will flow from the constant level chamber and back into the dip tank, maintaining a constant level in both reservoir and dip tank. As the lacquer level is lowered through use, the reservoir is refilled but only to that point on the dip tank level with the  $\frac{3}{4}$  inch or 1 inch horizontal pipe. The reservoir is filled when the dip chamber is free of a handle.

The number of applications will vary with the finish desired. Some lacquers require more coats than others because of the difference in hiding power of the various pigments and solids of the lacquers. Three coats are generally employed and are applied at varying intervals. Applications are squeegeed at intervals of one to two hours and sometimes as long as an overnight dry is given between the second and third coats. An overnight dry is necessary before shipment. Clear lacquers are squeegee coated over some colors to increase the lustre; in this event, two coats of color are used. Often a portion of the color may be added with the clear as the last application, resulting in a high lustre.

**FLOATING COLORS**—Lacquer or synthetic enamels are employed which are poured on the surface of a water filled container. (All enamels should be of the same consistency so that spreading over the water surface may be affected.) The enamels are floated on the water surface a drop at a time and precautions are taken to avoid splashing. The water surface is covered with four or five various colors which are allowed to "set" for a few minutes, and the object

to be coated is dipped into the mass with a slow motion, both immersion and withdrawal. The object after coating may be placed in a confined oven or such space allowing for thorough drying. Variegated color designs are obtained when the object is of an etched nature. To this end, if a lacquer first coater is applied, it should not be sanded, as smoothness will minimize the effect of blending the colors. By twisting or turning the object during the dipping operation, many novel color blending effects will result.

**COATING OF OBJECTS BY WHIRLING** — A washing machine is often used in coating small industrial items. This machine, of the centrifugal type, dries the objects after coating by a whirling action. Motion is produced by motor attachment.

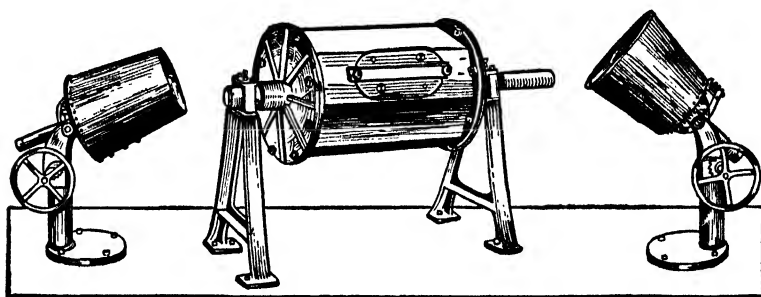
Small objects such as typewriter parts, handles and golf tees are handled by whirling and in bulk form. In the instance of golf tees which are coated in red and yellow lacquer colors, the procedure from a production standpoint should involve:

- (1) The lacquer is first placed in the chamber of the machine and reduced to applying consistency. This is determined by the hydrometer test, involving a Baumé reading. The lacquer thinner must be thoroughly agitated with the colored lacquer and the air bubbles allowed to rise to the surface and break before the hydrometer reading is taken or before actual dipping will occur.
- (2) When the proper body is reached, a removable tray is filled with the wooden tees and leveled by hand. This tray is fitted on a center shaft and is released by a foot-lever arrangement which lowers the tray containing the tees into the lacquer. This tray is completely immersed and with the foot lever it is withdrawn a short distance up the center shaft. The tray is held in this position for about a minute, thus permitting the excess lacquer to drip free of the chamber. When the excess lacquer is freed, the chamber is completely withdrawn and secured. The centrifugal or whirling operation is then started which dries the coated objects through its centrifugal force. After a few minutes of whirling, the machine is stopped and the objects which

have become coagulated are shaken free by hand and the centrifugal force is again set in motion. Several minutes of additional running will complete the operation. The tees are taken from the chamber and if a higher lustre is necessary, they are placed in a tumbling barrel with wax or old newspapers, etc., and through frictional tumbling the lustre is increased.

### Tumbling

Tumbling is a means by which articles may either be finished, cleaned, smoothed, brightened or polished. Its chief merit is economy in application. Of the many methods of applying lacquer coatings to



*Industrial Finishing*

FIG. 83. Tumbling barrels

small objects, the tumbling method appears to be one most widely used.

Tumbling barrels are either of wood or metal. The wooden type of solid construction is mounted on a trunnion and usually operated at about 25 R.P.M. The barrel is fitted with removable doors and cleats inside the barrel create a tumbling action. The type of lacquer employed is one of special construction and of heavy consistency which produces an eggshell finish. The less viscous lacquers which allow a maximum penetration should be used on soft woods.

The objects to be coated are placed in the tumbling barrels and the lacquer is added and revolved at a definite speed for a given time. Minimum amounts of lacquer are only necessary (as little as a "spoonful" being used in some operations). The tumbler is set in motion and the tumbling action quickly coats these small objects through

direct contact. After the objects are completely coated, they are taken from the tumbler and spread out on a tray for drying. After complete drying they are placed in a wooden tumbler, to which may be added sawdust, old newspaper or such abrasives and further tumbled to add a lustre to the coated objects. Wax, in hard lump form, is often added to this operation. The vertical (45 degree) metal tumblers are customarily employed as a cleaning tank for metal objects and may be also used for actual coating by tumbling. (See illustration No. 83.)

### **Roller Coating Process**

The roller coating machine as an applying medium of coating lacquers or synthetic enamel to sheet metal and similar porous and non-porous flat surfaces, is a system quite rapid and economical. This coating machine (see illustration No. 84) involves the transfer of the coating to a series of rollers. The object to be coated is fed between the roller surfaces and as it passes, is coated with the finishing material. The principle involved in this machine is as follows:

The coating is deposited into the reservoir; a composition roller running in this reservoir picks up the liquid, depositing it on the top steel roll in tandem series. The center roll, of rubber composition, next receives the material. The object to be coated is passed through the rubber and bottom steel roller. (This principle and device are similar to that used in the lithographing industry.) Great speed may be attained in coating with this system. Greater coverage will likewise result, as such difficulties as overspray occurring in spray application is entirely eliminated, and there is practically no material waste. Another advantage is the uniformity of material application. The type of lacquer for roller coating operation should be discussed with the supplier who, in view of the finish desired, should construct a product to meet these conditions. Such a lacquer should contain high boiling volatiles, as the lacquer must not set up too rapidly. Flow-out characteristics of such a deposited film are quite important. Check should be maintained of the viscosity of the material, and is usually enacted by periodic Baumé readings and necessitates additions of thinner in order to maintain a standard viscosity or body. Heavy bodied lacquers are used which result in high gloss finishes.

The rollers are of an adjustable nature and regulate the thickness

of the coating applied. A Pfund Film Gauge is used to calibrate the film thickness. A knife scraper is placed on the driving steel to prevent the material from being deposited on the underside. This excess lacquer is collected in a drip pan; roller adjustment will greatly minimize this condition. The surface to be coated must be thoroughly

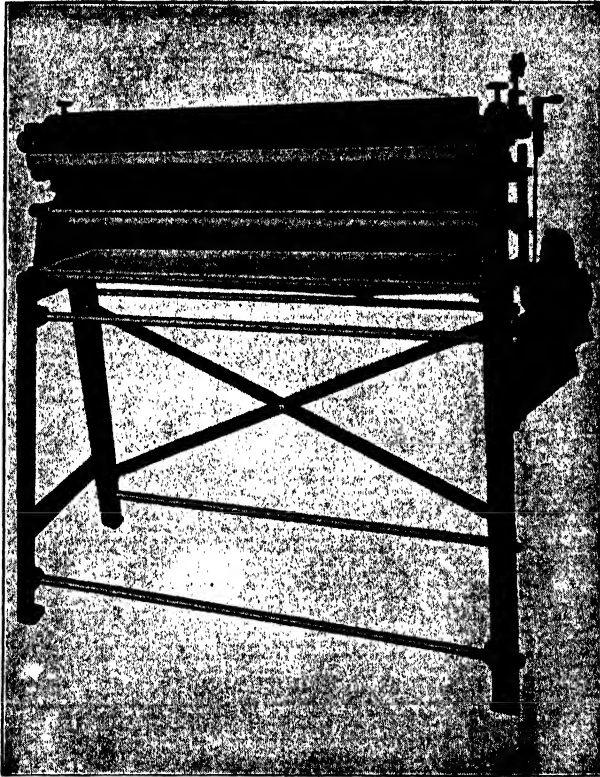


FIG. 84. Roller coating machine

*Nas-Dar Co.*

cleaned of grease and all foreign material if satisfactory results are to be expected.

These machines and this type of material are used in connection with automobile license plate coatings, and are involved in application of coating materials on the upraised numerals. They also find an outlet in metal can manufacture for lithographing purposes, and



as a means of reproducing wood grain effect on metal, also in metal sign coating, etc.

Roller coating machines are used in finishing venetian blinds, imitation wall tile and imitation floor boards.

**IMITATION WOOD AND MARBLE GRAIN ON WOOD** — Very desirable effects which depict wood and marble grainings may be reproduced on metallic surfaces. Such effects find numerous outlets in the metal industry, e.g., lamp bases, metal beds, cash registers, reproducing wood grain on automobile dashboards, etc.

Reproducing various grain effect is enacted in the following manner:

A wooden panel showing the grain effect to be reproduced is sanded smoothly and neutral oil is applied to the surface. The wood pores are well filled with paste wood filler. (Double filling from both sides of the panel is advocated.) The panel is photographed and engraved on a copper plate. Graining paste is applied to the plate and this paste is first worked well into the plate impressions with a scraper, which represents the grain and pores of the reproduction. A soft composition roller is then passed over the plate with a slow and steady motion. This roller picks up the graining paste on its surface, and is then passed over the work to be grained, which transfers the grain effect of the original to the copy. This operation may be applied by roller coating machines. Before the copy is applied, previous surfacing of the metal surface is necessary. Proper shades of colored lacquers are often used as a ground coat. After the copy has been transferred and dried, applications of clear lacquer are applied and the operation is completed. Graining tools are used which require experience in handling. Such tools are fitted with a wooden handle which is used to draw the tool over the surface. The ground coat of lacquer is first applied; graining paste is used, and the finish is top coated with clear lacquer.

In reproducing marble, the most prominent color in the marble to be imitated should be used as a "ground" coat. Method of finishing in this manner involves: (a) apply lacquer primer, (b) air-dry and sand, (c) apply ground coat, (d) sand, (e) grain, (f) clear lacquer.

### Silk Screen Stencil Process

The increasing use of silk screen stencil lacquers in decalcomania work and in metal sign finishing is due primarily to the three basic superiorities of modern lacquers over oil type paints designed for the same use. These three follow:

- (1) They permit succeeding colors to be applied in far less time than the oil paints.
- (2) Lacquers are more durable and are comparable in covering.
- (3) Lacquers possess greater elasticity of the applied film.

While silk screen lacquers have been on the market for some time, it has only been in recent years that they have reached their prominent stage. It can be stated that the universal acceptance of these processing lacquers came about with the replacement of oxidizing oils used in their structure, with synthetic resins.

Synthetic silk screen stencil pastes may be used which permit a thin film that may be spread producing greater flexibility, durability, and giving a sharp, clear print through the screen. Applications may be force-dried or baked and, where volume production is involved, it is more desirable to use this coating than lacquers, in view of the greater deposit.

The methods of making the stencils for use with the lacquer are as varied as the individuals who make them, each person having some ideas of his own which he considers superior to all others; however, the basic principles are the same and vary from the methods used to make paint stencils only in the materials used to block out the screen.

**THE FRAME** — The frame should be made of well-seasoned wood to obviate the danger of warping, and should be of a sufficiently large size to permit a space of 3 or 4 inches on each side of the design and of 6 to 8 inches at each end to act as a reservoir for the paste and a rest for the squeegee. The corners should be mitered and fastened by corrugated nails.

**THE SILK** — The printing space may be covered with bolting silk woven from the thread, free of knots, or with organdy. This latter has recently become extremely popular because of the heavy film deposited by lacquer through screens of this type, necessitating fewer coats to build up a heavy transfer and thereby making the oil paint

backing unnecessary, which is sometimes added to lacquer transfers to give them backing.

The silk should be tacked to the frame, stretching it tightly in such a manner that the threads shall run parallel to the frame; after which it may be reinforced by gluing heavy pieces of paper or webbing around the edge, both on the inside and outside where the silk comes in contact with the frame. This prevents excessive wear at these points where there is greatest danger of tearing.

**THE SQUEEGEE** — The squeegee may be purchased from the silk screen supply house or may be constructed by the user. The squeegee should be made of  $\frac{1}{8}$  inch rubber packing, trimmed to a smooth, even edge and mounted in a wood handle in identically the same fashion that the rubber of a window cleaner is mounted.

**THE STENCIL** — The photographic method of cutting in the design gives best results from a standpoint of minuteness of detail and clearness of design. It is satisfactory for use with the materials which must be used to block out the screen for use with the silk screen process lacquer. The pores of the screen are first filled with a water solution of gum arabic, which, after being allowed to dry, is followed by a coat of a special nitrocellulose lacquer designed particularly for this purpose. This is allowed to dry after which it is coated in a dark room with a gelatinous sensitizing solution which may be made by the user, but is best obtained from a silk screen supply house to insure absolute uniformity. The design is imparted to the screen from the photoengraver's positive print; this being accomplished by placing it in a photoengraver's printing frame in such a manner that the print is pressed tightly against the screen and then exposing it to the light from a photo lamp for from six to eight minutes. The print is then removed, and design upon the screen washed *from the side upon which the sensitizing solution was applied*, first with lacquer thinner, then with water. The screen is then ready for use. To clean the screen of the design it is only necessary to wash it first with water, then with lacquer thinner.

**DECALCOMANIA TRANSFERS** — A decalcomania transfer is usually made in a manner exactly the reverse of that employed to print a sign. That is, the base color or background is first applied to the prepared paper and the portions of the screen being blocked out which

will later appear on the design as another color. The second color is then applied over that portion of the uncoated paper where it is later to appear in the design, this being repeated until the design is complete, after which it is given several solid coats of some color, preferably white. The adhesive, consisting of a mixture of long-oil varnish and glue, is then applied and the transfer is complete.

**SIGNS** — The flat of the sign is finished with that color which is to be the background. The portion, not to be printed, which forms the background, is then blocked out upon the screen and the first color, usually the lightest, is then applied. This screen is then placed over the original print and the portion which is to remain in the same color as the first run is blocked out and the second color is applied. This is continued until the design is completed. Prior to the perfection of durable silk screen lacquers, these signs were usually made with baking enamels, necessitating the expense of installing and maintaining baking ovens.

Quite recently "synthetic" systems have been perfected which are adaptable to exterior signs. These are of the air-drying or all-baking variety and present greater durability and a higher gloss finish than a lacquer system. The primer and background colors may be roller coated and baked, the press-print applications may be baked or force-dried, and a clear protective coating may also be force-dried or baked.

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- (23) See paper "High temperature applications of nitrocellulose lacquers" — H. H. Nelson, Sharples Solvents Corp. — *Ind. & Eng. Chem.*, vol. 31, January 1939.
- (24) Davidson & Reid — *Paint and Varnish Production Manager*, January 1929.

## FURNITURE FINISHING

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### Wood

Wood, which is of the cellulose family, is of absorbent nature and has the property of changing its moisture content. This fact should be borne in mind when consideration is given lacquer or synthetic varnish applications as may be applied to this surface.

Such a structural surface is always subject to expansion and contraction with atmospheric changes. This tendency, with moisture changes, is not uniform, therefore severe strains are presented. Such expansion and contraction are essential from the structural viewpoint of the wood and it is only when and if such severe stresses are present after the wood has been coated that the finish is seriously affected. This condition is difficult to prevent and represents the hinging factor on which practically all finishing faults are blamed.

Under normal conditions, cellulose (wood) may shrink (through drying) or expand (through absorbing moisture) without damaging the wood, unless it is held by some outside means from expanding or contracting in its normal way. Under such circumstances many defects may develop which are often responsible for failures of the finish. The object of coating with lacquer and such finishing materials is to prevent undue shrinkage or expansion and prevent such defects as warping, cupping, twisting, cracking, etc.

Production methods involved in finishing furniture have indicated the following essentials: quick drying, hardness, and resistance to printing. A lacquer having these characteristics must partially sacri-

fice elasticity of the finish. For this reason, very rigid control is given the factor of apparent moisture content. The wood finishing lacquers or synthetic varnishes of today are considered sufficiently balanced to take care of minor changes in moisture content and at the same time consider the above desirables.

**THE STRUCTURE OF WOOD** — The various species of wood differ one from the other. Factors of soil, climate, light, drainage, etc., exert their influence on each tree. All wood, regardless of species, is composed of certain peculiarities of structure and composition, which have an important bearing on the moisture content. Wood is composed of groups of cells which form the wood tissue. These cells vary in size and type which are dependent upon the particular species. The cells, sometimes termed "fibres" are much longer than they are wide and are filled with sap which is primarily water. These cells become the "pores" of face veneer and must be filled with paste wood filler in order to produce a smooth finish.

There are two general types of wood: softwood and hardwood. The former is distinguished by its closed-end cells, while the latter is recognized by open-end cells. The hardwood variety is used mostly in the manufacture of furniture, oak, gum, walnut, mahogany, ash, maple, birch, elm, etc., comprising the general group.

Another form of cells present in wood is known as the medullary rays or pith rays. These cells extend toward the center or heart of the tree from the bark and conduct the sap from the bark to the heart. Medullary rays play an important part in the figuration or grain of wood when cut at different angles. In like manner, the annual rings also influence figuration, especially on plain and sawed faces. Heartwood is highly prized for furniture since it has beautiful grain and color.

**MOISTURE CONTENT** — The moisture content of wood is expressed as the amount of water in the wood pores and will vary considerably according to species and locality in which the tree is grown.

The amount of water contained in wood whereby the cells and walls are filled is the fibre saturation point. When the moisture is expelled the wood shrinks, conversely when the wood absorbs moisture, the surface will expand. It is such action which causes finishing film failures. In the course of kiln-drying of wood, care should

be given the factor of low temperature and high humidity conditions, as wood so subjected will shrink to a greater degree than wood that is dried at higher temperatures and low humidities. Wood that has been properly kiln-dried does not appear to take on moisture as readily as it would if it were air-dried. The moisture content of furniture woods should be about six per cent.

Relative humidity will incite an influence on the moisture content of wood. For this reason, atmospheric conditions should be controlled in the seasoning of wood. Relative humidity is described in Part III, Chapter X, subject TESTS.

### **The Bleaching of Wood**

It is often desired to have certain portions of furniture appear in a lighter shade than the particular variety of wood will permit. This may be exemplified by the center panel of a radio cabinet, center of a drawer or back section of a chair. Shading lacquers are frequently used, but where this is not practical, the wood is bleached to a lighter shade.

A powerful bleaching agent employed on walnut wood is sodium bisulphite, which is dissolved 6 ounces per gallon of water. This solution is applied on the surface to be bleached and while it is still wet, a solution made of 8 ounces oxalic acid per gallon of water is applied. Bleaching action is terminated when the water has evaporated. The surface should require a longer drying time in order to control the moisture content of the wood through the introduced water. In view of a desired lighter shade, the paste wood filler should be of a natural color, instead of one of the walnut fillers. After bleaching and filling, the operations to a finish involve sealer and finishing lacquer or synthetic varnish.

Where different kinds of wood are employed in the structure of furniture, a bleaching agent or solution is frequently used in order to equalize the color of the woods. A combination of lacquer-bleach is frequently used.

The French or Huguenot walnut finish most frequently involves a bleaching agent or solution; a typical schedule follows:

One ounce potassium permanganate per gallon of water. Apply to the surface and while still wet, apply a solution of three ounces of

sodium bisulphite per gallon of hot water. Cool before using, apply sealer coat, filler, lacquer or varnish to a finish.

### **The Staining of Wood and the Use of Stains in Furniture Finishing**

In the logical finishing of furniture it is common practice to stain, fill and then apply finishing lacquers or synthetic varnishes.

The best grades of wood were used in the earlier days of the piano and cabinet industry. Walnut, mahogany, and such woods then in use required no stain to enhance their beauty and to intensify the natural wood grain. With the supply of these woods gradually becoming depleted, attention was directed toward wood considered inferior at that time. These so termed inferior woods were put in general use and required the use of stains to more nearly approximate the true grain and imitate walnut, mahogany, etc. Stains were at the same time used on walnut, mahogany, etc., to produce uniform coloring of the wood, to produce color depth, clarity of tone, and to bring forth the natural grain in a more pronounced manner.

Stains used in the earlier days of finishing were customarily made by the individual operator, while today stains are secured from the various suppliers who make a specialty of their manufacture. Such stains are secured in a mixed state and are ready for application, or are secured in powder form. The former is the most common practice.

There are three distinct types of stain used in wood finishing practice which are termed: powder stains, liquid stains, and non-grain-raising stains. The latter type is of recent development and has, to a large extent, replaced the two former types.

**POWDER STAINS** — As the name implies, these are dry powders which are dissolved in various liquids. The powder stains are referred to as being water soluble, spirit soluble, or oil soluble stains.

**Water Soluble Stains** — These are powders that are readily soluble in water. They are aniline dyes and are used to a large extent in the woodworking industry. They are also referred to as **ACID STAINS** when they are used in other industries. These stains produce good tone depth and permanency of color when exposed to the action of sunlight.

With the study devoted to faults and corrections of lacquer finishes in recent years, water soluble stains have come in for certain criticism.



The drawbacks of water stains are: raising of the grain of the wood and the long time that is involved in drying before further applications, to insure proper moisture content of the wood.

**Spirit Soluble Powders** are similar to water powders, except that the solvent used is alcohol. These stains are the least fast to light of all stains and are great offenders of "bleeding" through applied lacquer or synthetic varnish.

**Oil Soluble Powders** — These are usually aniline dye colors soluble in oils, aromatic hydrocarbons, and similar liquids. These powder liquids are penetrating and produce clear tones. They are slow drying and do not raise the grain of the wood as do the water and spirit soluble powders, however, they do not produce uniform staining as do water soluble or non-grain-raising types. They find use as the cheaper furniture finishes.

The **LIQUID STAINS** have the same characteristics as the powders, except these are supplied in liquid form.

A type of liquid stain referred to as surface stains is involved in a solution of such opaque pigments as umbers, siennas, etc., which are dissolved in turpentine, driers, etc. This type is used to obscure the grain of the wood, rather than to intensify it. In this respect, it is compared with a shading stain.

**Chemical Stains** — These are stains which depend upon a chemical action to promote the desired coloring effect, such as tannic and picric acids, potassium permanganate, etc. These stains require exact and careful handling and are not used in modern furniture finishing practice. An example of the use to which this type of stain is put is involved in staining oak a silver gray. This is produced with tannic acid and copperas dissolved in water.

Advanced methods in furniture finishing, quicker finishing schedules, etc., indicated a need for a permanent stain which would comprise the good features of water and oil stains and which would retard or eliminate the action of raising the wood grain. Such stains are presented and termed **NON-GRAIN-RAISING STAINS**. These stains have been well received as they obviate the collection of dust during drying and eliminate the usual "shellac sealing." Such stains produce rich even tones on the work and dry to permit filling operations in thirty minutes after application.

Non-grain-raising stains of liquid nature are ready for application and do not require additions of water, bases, etc. It is usual practice to ship these stains in concentrated form, which may permit reduction before use. They are of a permanent nature (fast to light) and will permit a uniform color on wood surfaces. These stain solutions will not raise the grain of the wood, even when applied in a relative humidity as high as 80 per cent. Through the use of this type of stain, shellac or other media acting as a wash coat, is obviated, hence effecting a greater economy through their use. This feature likewise eliminates the sanding operations and prevents pinholing. These stains will not bleed when lacquers or varnishes are applied and may be applied either by brush, spray, or dip applications. Non-grain-raising stains require a special thinner which is made up of the special solvents that are used in its structure. This thinner should be used whenever reduction is necessary; either to compensate for the loss through evaporation or for "toning" purposes, where a lighter shade is desired.

Non-grain-raising stains may be secured in primary colors which, through intermixing, will permit the operator to arrive at any shade desired within this scope.

The particular use and application of stains has bearing, of course, on the size and shape of the object on which it is to be applied, type of stain being used, kind of finish that is desired, finishing room conditions, and method of application.

Stains applied by the brushing method is common procedure and is said by some experienced in the art to give best results. A flat type, fine bristle brush is used. The application of stains should take place at room temperature, and regardless of the manner of application, too much emphasis cannot be placed upon the importance of allowing the stain to become thoroughly dry before applying the next coat. The drying and durability of all succeeding coats may be affected by crowding the drying time of the stain and the small amount of time gained is frequently more than lost on other coats and in poor results.

The design of certain objects may indicate dipping method of application to be most economical. Where the natural flow is secured, this method is quite practical. The stain should be well agitated and

maintained at a uniform temperature. Excess stain should be wiped free shortly after withdrawal from the dipping tank.

Where large flat surfaces are involved in staining, applications by the spray method are employed. If the stain is properly applied, it may be considered an economical method. An old spray gun is used; one that has outlived its usefulness for fine lacquering, although one that will apply the stain in an even manner. Two coats are usually applied, the first a light cross-grain coat, followed by a medium application with the run-of-the-grain. Low air pressure (about 15 to 20 pounds) is used in this application. The material loss through overspray may be more than counterbalanced by the speed of application.

Irrespective of the type of stain employed and the method of application, it is necessary that the surface of the wood is in proper condition to receive the stain. The wood should be properly dried, sanded smoothly and the pores should be free of dust. After the application of the wood stain and before filling, the stain must be thoroughly dry, as on this hinging factor will depend exact results.

Care should be given the selection of stain for use under lacquers. Some of the more common causes of improper selection and hastiness are: improper drying, bleeding, precipitation of the nitrocellulose, adhesion, etc.

### **Paste Wood Fillers**

As its name would imply, paste wood fillers are a media of paste-like consistency and are used to fill the open pores of wood surfaces. Such filling applications prevent undue absorption of lacquers by the wood. Paste wood fillers in this respect hold out applied lacquer coatings on the surface of the wood.

Fillers are usually applied following complete drying of the stain. Paste wood fillers, in some instances, are employed as a combination stain and filler, although this is not common practice. As in the instance of the earlier stages of furniture finishing, fillers, like stains, were commonly made by the individual operators.

Vegetable products like cornstarch and wheat flour were used, along with linseed oil. Today paste wood fillers are secured from the various suppliers who specialize in their manufacture.

Paste wood fillers are approximately of the same color as the stain

which will permit the same appearance throughout the surface and are composed of inert pigments, characterized by silica and clay; earthen pigments for coloring matter and proper oils and binder.

Paste wood filler, which is in the category of a varnish type material, is reduced with naphtha and usually applied by hand brush applications, although in some instances, it may be either dipped or sprayed. Brushing methods are commonly employed as there is less danger of having unfilled pores in the wood surface. After application, the filler is permitted to "flatten out" and after "flattening" which is characterized by a top drying appearance, the filler is padded into the pores of the wood, usually with a pad made from burlap, hemp or jute tow, or may be rubbed in by a rotary motion of rubber pads attached to a rubbing machine. A circular motion is used to insure thorough filling of the wood pores and the excess is cleaned from the surface with a clean rag. Such cleaning is executed by hand and across the grain of the wood, using a little pressure on the pad. This action will further tend to fill the pores of the wood. After the excess filler has been wiped from the wood, it is permitted to dry in accordance with the necessary drying time, which is in view of the particular type of filler being used. Paste wood fillers should be bone-dry before succeeding applications of lacquer or varnish are applied.

Prior to the use of quick drying paste wood fillers, such products required at least a forty-eight-hour drying period before the application of lacquers or varnishes. The quick drying paste wood fillers of today are constructed so that they are sufficiently dry to recoat with lacquer in three to four hours after application. The long drying of former types of paste wood filler had been a great handicap in the form of an item of expense through storage space required and money spent in tying up semifinished products and delay in getting out rush orders. Quick drying paste wood fillers permit staining (non-grain-raising type), filling, and lacquer coating of furniture, packing and shipping all in the same day. This is a saving of at least three days over the former method. In this respect, quick drying fillers are an advantage; however, for certain types of work, the older type of longer drying fillers are better suited and are still in use.

Paste wood fillers, as well as the staining operation, are all-

important in the successful application of lacquers and varnishes. Improper filling as a result of a poor filler, careless methods, etc., are basic causes of finishing troubles. All work leaving the cabinet room should be smooth and well sanded. The pores should be free of fine dust particles, otherwise the pores will not properly hold the filler. The filler should be applied sufficiently heavy to fill the wood pore level. The more open the wood pores, the heavier the filler should be used. It has been found that the ratio of reduction is about 12 pounds of filler per gallon of naphtha. This will govern the average consistency of application. Naphtha is commonly used, although gasoline is sometimes used. It has been found that the latter is often responsible for spotty drying of lacquer, because of an oil base present in the gasoline. This should be carefully watched.

Filler should be kept well agitated and where a small container is used, the filler should be "stirred" each time the brush is taken from the pot. Certain production establishments employ an air line attachment from the spray line to "bubble" air through the mixed filler and insure it being mixed thoroughly. A well-compounded wood filler will not settle and should require only a minimum amount of agitation throughout the day.

Among the desirable properties of a quick drying paste wood filler, the following should be considered:

Dry to recoat in approximately three to four hours.

Must be workable.

Must be suitable for use under lacquers.

Must fill and pad well.

Must not shrink in the wood pores.

Must not bleach or turn gray under lacquers.

Must wipe clean and produce a clear tone under lacquers.

In view of the quick drying nature of this type of filler, relatively smaller sized surfaces should be coated at an application, to permit wiping before the filler becomes too hard.

It is permissible to apply the filler by spray application. An old gun (one that has outlived its usefulness for lacquer work, but one which will permit a fanlike spray) is usually employed. The filler is reduced to applying consistency for the method of application and is usually double-coated; that is, the operation is reversed,

It is important that proper air-circulation be considered in the drying of applied paste wood fillers. The work should be stacked to permit a free circulation of air which may contact all filled surfaces. The relative humidity (about 38 per cent) should be maintained at all times.

Single filling, if properly executed, gives better results than double filling. If double filling is resorted to, the second application, in addition to being applied cross-grain, should be applied opposite to the direction (across grain) to the first filling operation.

### Undercoat or Sanding Sealer

It is the function of an undercoat or " sealer coat " to seal the paste wood filler which has been maintained at a level surface, and at the same time, to act as a foundation coat for further lacquer or varnish applications. The finishing of wood is opposite to that of finishing metal, i.e., the purpose in finishing wood is to reduce porosity to prevent undue absorption while the finishing of metal involves a roughening to increase the strength of bondage between the metal surface and the applied coating.

In the earlier days of furniture finishing and to some extent today, shellac was used as a sealer coat. (The use of shellac as a sealer under lacquer is treated elsewhere in this chapter.) In order to eliminate faults that are directly attributed to the improper use, handling, and storage of shellac employed as a sealer coat, products termed " clear lacquer undercoats " or " sanding sealers " are used. These nitrocellulose products which are applied by spray application at pressures ranging from 30 pounds to 100 pounds have met with great favor. They are formulated of materials which permit developing a " tooth " for the sandpaper or steel wool to grasp and they " powder white," comparable in this respect to the similar action of shellac. Lacquer sealers dry by evaporation and tend to " seep " into the pores of wood filled with wood filler and thus produce an ideal foundation for lacquer. These sanding sealers may be hand or machine sanded 30 minutes after application and may be lacquer coated immediately thereafter.

Sanding sealers are usually shipped at applying consistency, although some are of a heavier consistency. The former is best suited

in view of the fact that this application maintains a foundation or structural characteristics of the lacquer surface and should therefore be of a high solid content which will permit securing a maximum foundation on the work. The use of a product necessitating reduction, reduces its ability to present such a structure.

In some establishments "sanding sealers" are used as a finishing lacquer. From its structure, the media through which ease of sanding is characterized would necessitate resin and/or a flattening agent. Sealers produce a satisfactory flat lacquer, having the appearance of a rubbed finish. Sealers used as a final coat application on furniture is subject to "scratching white" with very little effort. To obviate this, certain establishments apply a liquid wax and if this is done, care should be exercised that the application of wax is not in too heavy a manner as it may soften and/or precipitate the nitrocellulose.

Through the advancements in compatible raw materials, sealers were recently placed on the market which presented marked improvements in "solids on the work" at spraying consistency. Today these products show around 21% to 27% total solids which, allied with the increase in other finishing materials (clear and flat lacquers), will truly realize a typical varnish fullness. Such a finish is attained through a limited number of applications.

A typical formulation of sealer (solids) is as follows:

|                            |             |
|----------------------------|-------------|
| Nitrocellulose (dry) ..... | 35.00% b.w. |
| Resins .....               | 57.00       |
| Metallic soaps .....       | 8.00        |
|                            | <hr/>       |
|                            | 100% b.w.   |

### Sandpaper and Sanding

A firm foundation produces a surface which may result in durable structures, or in this case a firm "tooth" on which succeeding applications of lacquers may be applied to a lasting finish.

Lacquers dry rapidly by the evaporation of their volatiles and in drying will gain an anchorage by penetration into surface imperfections and produce an uneven appearance. In order to produce a satisfactory velvetlike appearance so rich in beauty and lustre, rubbing and polishing are required. This operation magnifies any surface depressions that may be present. A lacquer surface should be wet sanded

as this operation produces a level surface which will readily accept rubbing and polishing compounds and produce a surface free of depressions. Water lubricates the cutting medium, prevents scratching, and hardens the surface. It also prevents sanding dust which is a health menace.

Sandpaper is used in the planing room to surface furniture before the application of coating materials. The sandpaper is usually mounted on a block or pad which may either be constructed of hard rubber or felt. With today's finishing trend, having a leaning toward synthetic resinous compounds (both lacquer and varnish types), the use of oil as a lubricant should be avoided. Water will tend to harden a surface of coating material while oils will soften it.

In the woodworking industry the use of a portable sander, which may be used for fine design work on furniture, meets with great favor. Such a sander is of sturdy construction, yet is light in weight and may be operated from a light socket. This type of portable hand sander may be equipped with a dust removal system which collects the dust in a bag attached, similar to the receptacle on electric sweepers. This type of sander has been received with great favor, as it eliminates a great menace to workmen — dust.

### Shading Lacquers

Shading lacquers are used to highlight furniture on corners and edges which are so easily cut through in the sanding operation and to uniform inferior woods used in furniture construction. As an example, when walnut, gum and willow may be used in the construction of a radio cabinet, shading lacquer may be employed to equalize the color of gum and willow to that of the walnut.

Shading lacquers are applied by spray application and require low air pressure on the gun. The lacquer should be well atomized and applied in an even manner. Shading lacquers are of concentrated nature and should be reduced for lighter "toning" purposes. The trigger finger of the operator has great bearing on the ability to blend properly the stain or shading lacquer in a satisfactory manner. Shading lacquer applications are applied directly over the lacquer sealer (after sanding) and are, therefore, sandwiched between it and the



clear or flat finishing lacquer. Such finishing applications will then magnify the shading lacquer to the desired effect.

### Clear and Flat Wood Lacquers

Manufacturers of nitrocellulose lacquers undertook a big order when they set out to replace varnish as a finish for furniture. Many recall the difficulties met with in these earlier days. Lacquers gradually reached the point where certain of these difficulties were overcome. The fact of rapid dry, tough and impervious film remained in its favor. Today, through the use of synthetic resins, the cherished desire of the lacquer technician has been reached; that of producing a quick drying coating, having the film deposit of a varnish — such a finish is *lacquer*.

Wood finishing lacquer technique has advanced quite rapidly, whereas, in the earlier days with limited solvents, resins, etc., a solution would dissolve only a limited amount of solids. If greater amounts were introduced, the solution so formed would become inactive and the solids would remain visibly in suspension. The advent of low viscosity nitrocellulose, wider range of solvents, plasticisers, and synthetic resins are responsible for the transformation.

A comparison of varnish and lacquer with respect to their drying is as follows:

“Varnish dries by oxidation. The resultant film deposit is composed of gum resins and oils. Oxidation proceeds until an oxygen saturation point has been reached. As long as a varnish film can absorb oxygen, it is considered ‘alive.’ When oxygen can no longer be secured, the film becomes lifeless, hence, oxygen, besides acting as a drying agent, is also the agent of destruction. The moisture contained in the air is responsible for the short life of the varnish film, permitting dampness to enter through formation of pinholes.

“Lacquer dries by the physical action of evaporation. The feature of harmonious composition of solvents is quite important. These are controlled by the vapor pressure of the various solvents used. Total solids or film formation, which remains after the volatiles have left the film, are composed of nitrocellulose, gum resin, plasticisers, and/or metallic soaps.

“As the volatile solvents escape, the resultant film formation is

neither affected by weather nor climatic changes. Lacquer may be formulated which deposits a tough and impervious film, permits rapid production through its quick drying features, allows freedom from softening and printing in humid weather or cold checking in zero weather, and does not sweat after rubbing. Lacquers are impervious to hot dishes and boiling water, alcohol and abrasion."

The building properties or apparent depth of a lacquer film depends on the total solids of the particular lacquer at the applying body or consistency. Proportionate amounts of each of the solids also affect the particular appearance of the lacquer. An example of this is a lacquer having a high percentage of gum resin. Such a lacquer film will permit a high gloss film having the appearance of great depth. Such a lacquer in a wet state, looks "thicker" than a lacquer which contains the same solid content in a balanced ratio of gum resin and nitrocellulose.

Nitrocellulose is responsible for the durability of wood finishing lacquers. Undue proportions of gum resin to lacquers produce great building properties, but at a sacrifice to durability (certain of the synthetic resins are an exception).

Wood finishing lacquers dry dust free in a very short time, therefore rubbing between coats is unnecessary; sanding is also unnecessary. (Some wood finishers advocate either hand or machine sanding between coats.) Where sanding between coats is practiced, it would be necessary to produce a lacquer that was short-brittle. For the lacquer manufacturer to supply an easy sanding lacquer would be to sacrifice durability — with respect to elasticity of the film. (Let us not forget that woods expand and contract under conditions of both temperature and moisture changes.) An "elastic" type of lacquer is required to comply with the movement of woods. Other than for the "knocking off" of the wood nibs, etc., on the first coat, sanding between coats is unnecessary.

Scaling in lacquer finishing is unknown. As each succeeding coat of lacquer is applied, it dissolves with the previous coat and becomes one continuous film from filler to finish coat.

Wood finishing lacquers should always be secured at an applying consistency. It is false economy to introduce thinner and thereby attempt to cheapen the cost "at the gun." Thinner is volatile and

will evaporate entirely from the film; furthermore, in order to permit volume reduction of lacquers, it would necessitate the use of a viscous, or in the case of wood lacquers, a false body, in the structure of the lacquer, which is usually presented in the form of a high viscosity nitrocellulose. True film building properties presented at applying consistency are desirable characteristics.

Quite recently, through advancements in raw material development, clear wood lacquers have been perfected which show a marked increase in total solids at applying consistency. Such finishes permit nearly approximating the apparent fullness of a varnish — still retaining all of the desirables of a lacquer. The total solids of such lacquers are around 21%–27%.

The finishing of furniture with “high solid coatings” is undergoing serious investigation at this time. Lacquer emulsions and “hot lacquer coatings” being considered outstanding developments to date.

Flat lacquers are, in reality, clear lacquers to which have been added a medium which duplicates the appearance of a rubbed finish. Such lacquers reduce the cost of the rubbing operation. Wax, pigment (metallic soaps), or gum resins are used to produce a flat lacquer. These finishing lacquers are based on high solids (21%–27%).

### Period Furniture Finishes

Period furniture finishes are produced on walnut woods and are usually involved in staining, which is composed of both a walnut color and a black. It is high lighted by sanding around the drawer-pulls, etc. Filler application is dispensed with and the lacquer and/or wax is used as a finish. Oak wood is also used and the schedule is as above. Jacobean stain is used on oak woods. When mahogany wood is used, the filler is applied over the stain and the final finish is not high lighted.

**QUEEN ANNE FINISH** — Walnut and mahogany woods are used. The finish involves stain, filler, and lacquer. The lacquer is rubbed to a dull finish or flat lacquer is used.

**FINISHING INLAYS** — Inlays are used in table and cabinet construction, etc. They are usually stained before gluing and the filling and finishing operation is enacted in the usual manner.

**MAPLE FINISHES** — Maple wood is usually finished with a natural colored filler. Certain pieces are given a mild stain application of a yellow tone. Curly and bird's-eye maple may be stained, filled, and finished in the usual manner. Gum, basswood, birch, and tupelo are often stained and used to resemble maple finishes.

**GUMWOOD FINISHES** — Uniforming gumwoods is a trick of shading or blending of stains. The trend of times involving cheaper furniture and the unavailability of certain woods has dictated this procedure.

### **Veneer Surface Finishes**

The fact of frequent variations in moisture content on this thin surface may lead to warping and result in surface finish defects. Such thin veneer not only absorbs and gives off moisture more readily than heavier woods, but its strength is greatly reduced and it is more subject to checking and cracking with a change in the moisture content. Thorough protection of the wood from external atmospheric influences is very important. Non-grain-raising stains are frequently used on veneered surfaces.

**MAHOGANY FINISHES** — Mahogany wood is accepted as the premier cabinet wood of the world. There are three general type classifications: West Indian, American, and African Mahogany. The West Indian type is preferred because of color, texture, and grain. The American type will vary slightly in figure, texture, and color and it possesses a straight grain and a yellow texture. African Mahogany possesses a milder texture and larger pores than the American or West Indian.

The red-brown finish in mahogany predominates for furniture and cabinet work and certain schedules involve a straight brown tone. Non-grain-raising stains are used, followed by filler, sealer, and finishing lacquers.

**PHILIPPINE MAHOGANY** — This wood is of a more porous nature than the true mahogany and contains larger but more shallow pores. This condition presents a wood somewhat harder to finish free of pin-holes, shrinkage and such defects. The proper handling of this wood, however, will permit a satisfactory finish, as it presents a good figure.

Common practice is to water sponge the wood with warm water to raise the loose fibre. This is permitted to stand overnight to insure

entire evaporation of the water. Following this, the raised fibre is cut clean using a very fine grade of sandpaper. The paper should be sharp so as to cut the fibres away clean and not merely wear them off. Immediately following the sanding, the staining process is carried out. Non-grain-raising stains or water stains are used, which will produce a clear and uniform shade. The water sponging operation is often dispensed with when non-grain-raising stain is employed. If water stains are used, they should be used weaker on Philippine Mahogany than on African or Central American Mahogany. After the customary allotted drying time (in respect to the type of stain used), the surface is sealed with lacquer sealer. A very thin coat is used, which is lightly sanded and followed by filler application. This sealer coat tends to "seal" the stain (before filling) and permits a clean reproduction and magnification of the true grain effect. Quick drying fillers are used and are applied with care and in the usual manner. In fact the greatest of care should be taken to avoid pinholes, for some of the wood pores are connected one with another by U-shaped channels below the surface of the wood. Although the two openings of such pores may apparently be filled with the filler, a quantity of air may be entrapped in the new portion of the pore, and with a change in temperature, will expand and may form an opening around the filler in one or another pore. This may result in the finishing lacquer penetrating into the open pore, liberating trapped air and forming a pinhole. Other pores are long and shallow, having the appearance of a groove. Paste wood filler when used on this type of wood should be used heavier than on other woods; double filling is frequently resorted to, the first fill being a little "thinner" in body than the second. Care should be exercised in the wiping of the filler so that the "worked in" filler is not disturbed in the wood pores. The filler is sealed with a lacquer sealer. Thin applications are used and sanded before the lacquer is applied. Clear or flat lacquers may then be used to a finish.

**WALNUT FINISHES** — Walnut wood yields a variety of beautiful and very distinctive figures. It is the only species which yields the highly decorative stumpwood so prominently employed in veneers.

Some of the choice "cuts" of walnut are: crotch, burl or swirl, sliced and quartered, rotary and half round, and stumpwood. Varia-

tions of these "cuts" made up in panel form are: feather crotch, moonshine crotch, plain sliced, quartered sliced (mottled figure), figured sliced (mottled figure), figured quartered sliced (plain figure), figured rotary, quartered rotary and quartered rotary (fiddle-back figure).

The finishing of walnut wood is enacted in the same manner as other woods, e.g., stain, filler, sealer, and clear lacquer.

### Rubbing — Polishing — Buffing

Best results are secured if the wood is properly filled and surfaced. The thoroughness of sanding in the planing and cabinet rooms will influence a first class job. In like manner stains and fillers should be properly applied and thoroughly dried. With the foundation thus assured, the clear lacquer or varnish should be applied in thin and even coats. Sufficient time should be allowed for drying between coats to secure as fairly a continuous and level a surface as possible. It is common practice to apply the last coat of material somewhat "thinner" than the previous coats.

A very fine grade of sandpaper is used with water as the lubricant. 320 to 400 waterproof paper is advocated and the water is used freely in order to eliminate any tendency toward caking. A rubbing compound is sometimes used, although it has been found that "wet or dry" sandpaper is faster. This action "cuts" the top of any orange peel and leaves a smooth finish.

**HAND RUBBING** — Straight and even strokes are necessary. Do not exert too much pressure as this will tend to produce scratches.

Fine pumice stone and water or a thin non-drying oil is used (neutral oil has found great favor). A felt pad about  $\frac{1}{2}$  inch to 1 inch thick and 2 inches wide and 4 inches long is used. This felt is mounted on a block with the ends turned and securely tacked in place. The rubbing pad should be thoroughly wetted when in use.

Rubbing is executed with the length of the wood grain. Long full strokes with the same exerted pressure throughout the stroke is desired. Rubbing mediums are: pumice stone, rottenstone, carborundum, charcoal, chalk sandpaper, and compounds.

**MECHANICAL RUBBING** — A machine used for mechanical rubbing consists of a rubbing machine, flushing attachment, and a moisture

trap. The machine involves a heavy metal body to which rubbing felts are attached. The machine is operated direct from the compressed air line. A moisture trap is necessary to insure dry air, free of oil and moisture. The flushing attachment is optional, depending on the nature of the work to be done. It is used primarily for all water rubbing, as it eliminates the danger of "burning" the surface due to dry rubbing. The flushing attachment is eliminated in connection with oil rubbing.

A medium grade of rubbing felt should be used and the felt is attached to the plate on the machine by screws or by heating the plate and placing dry flake shellac until it melts. The shellac adhesive is impervious to the oil and/or water. In continual operation, the lubricant for rubbing (oil or water) is kept handy and the felt is set in this lubricant when not in use.

A pneumatic pressure arm may be installed which enables an automatic lift to raise the heavy machine from the work. An overhead track facilitates wide range operations. Uniform pressure is one of the most important requisites in obtaining smooth finishes. An air regulator adjustment permits this control, which will vary with surface hardness.

**COARSE RUBBING** — Coarse rubbing is only resorted to when the finish is to be polished. Powdered pumice stone and water are used. A rubbing pad or burlap is used and the latter only until about half rubbed, then the felt pad is used. Steel wool is used today to a large extent for coarse rubbing.

**DULL RUBBING** — Fine powder pumice stone is used with water or oil as the lubricant. A felt pad is used, burlap or steel wool may also be used. Rubbing is followed with cheesecloth and oil.

**OIL VS. WATER RUBBING** — Water rubbing cuts more readily than oil, although water rubbing does not permit as dull a finish as oil. Where an extra dull finish is desired, it is often advisable to water rub followed by oil rubbing. Where oil is used as the lubricant, it should be removed from the surface as soon as possible because of the tendency to soften the finish.

**FINE RUBBING — HAND RUBBING — POLISHING** — After the finish has been rubbed to a dull finish with pumice and water, it is polished by what is termed, fine rubbing. A felt rubbing pad is used with

rotenstone as the cutting abrasive and oil in place of water. A final rub, using the palm of the hand with rottenstone and oil, follows. The surface is cleaned with a benzine dampened soft cloth and rubbed dry with a chamois skin to a polish.

Polishing and buffing mediums are: linen, paper, flannel, cotton, sponge, chamois, rouge, and compounds.

**FRENCH POLISHING** — This is the application of shellac by cloth to a wood surface. A rubberized cloth is used and shellac is employed as the only coating, polishing, etc. The shellac is applied throughout (in the wood pores and from thence to a finish).

**BUFFING** — A mechanical buffing wheel is often used, both for rubbing and polishing operations. This device is formed of a portable base to which is attached a flexible shaft. It has met with good success in the automotive industry. Sheep's-wool buffs are employed. There appears to be the possible difficulties of too great a speed involved on these mechanical buffers as applied to wood surfaces which do not carry off the generated frictional heat sufficiently fast enough.

**ROTTENSTONE** — Also termed Tripoli. This is a limestone which is imported from England and Belgium.

**PUMICE STONE** — This rock-form or ground pumice is of volcanic origin, and the pure Italian pumice stone is best suited for rubbing. Grades from 4F to 7 are used in the furniture industry; the former is the finest grade.

**RUBBING OIL** — This is a mixture of equal parts of alkali free neutral oil and kerosene and is used as the lubricant in certain rubbing operations.

### **Sandblasted Finishes**

In the furniture field sandblasting is used in order to reproduce an age-worn and roughened surface effect. A mechanical device, patterned in part after spray equipment, is used to direct the sandblast. A hard rubber stencil is used to "block out" any section of furniture not desired in this roughened effect. With the stencil placed securely, the nozzle is directed onto the work. A range of 60 to 90 pounds pressure per square inch is used. The portion on which the sand is directed will appear in deep weatherbeaten gouges or sections. (See illustration No. 85.)



The use of sandblasting for panels, doors, pictures, or interior decorations in homes, clubs, or hotels presents a beautiful and striking finish. The wood is received by the assembly room "in the rough." Sanding is unnecessary and no attention is paid to worm or knotholes, checks, or cracks in the wood, as these defects are more advantageous for effect. In making the stencil, a paper pattern is used. A rubber stencil (jiffy stencil) is drawn and zinc is used for the backing (the rubber being the face and the zinc the backing of the stencil). These



FIG. 85. Sand blasting

*Industrial Finishing*

are secured together through hot caulboards and subjected to pressure. In making the stencil, care should be taken in producing a uniform cut. After sandblasting, the surface is cleaned to remove traces of sand. The surface may be stained and filled and followed by a light spray coat of lacquer to a finish.

The effects of carvings and overlays may be secured through sandblasting. The experience of the operator and manner in which the sand is directed as well as the pressure and time allotted a definite surface has bearing on exacting results.

### Colored Finishes

Where colored finishes are involved in furniture finishing, lacquer or quick drying synthetic enamels are used. The woods are of the

cheaper grades because of the fact that the grain is completely covered with the opaque material. Pine wood is commonly used for colored furniture. Breakfast sets represent the common type of furniture on which this material is employed.

The wood is sanded thoroughly in the white and is then coated with opaque surfacing materials; oil undercoats are most frequently used. These require an overnight drying period, at the end of which time they are either dry or water sanded and the lacquer or synthetic



*Industrial Finishing*

FIG. 86. Colored finishes

enamels are applied. Such enamel base material must dry hard enough to allow the application of lacquer enamels without disrupting the finish. Lacquer primer-surfacer combinations may be used in place of the oil undercoat material. This procedure will permit a more rapid schedule as the primer-surfacer is of a much quicker drying nature and will accept lacquer applications about one hour after application. The lacquer enamels are basically of the same general structure as automobile lacquers. They are resistant to the elements, etc. (See illustration No. 86.)

### **Decalcomania Transfers**

These paper transfers are used on furniture, glass, celluloid, metal, parchment, cloth, etc., and such lacquered articles for decorative purposes. They are used to gain unity and add to the appearance of the object on which they may be applied.

The furniture is finished in the regular manner and the transfer is placed in the exact spot where the most appeal is to be gained and a chalk mark is used as a guidance. The transfer is coated with a film of cement or special coating that is to be used. The transfer is allowed to dry and set until a slight "tack" remains and the transfer is then laid between the chalk marks. A roller device is passed over the transfer to free the air bubbles which may have been captivated and also to roll the excess liquid to the edges. After the transfer is leveled, it is allowed to remain or set for about three minutes. The surface is then saturated with water which is applied with a sponge. This action loosens the paper on which the transfer was applied and the paper will leave with the transfer remaining. A reasonable time is allowed for the moisture to leave the surface and a protective coating of clear lacquer may be applied to a finish. When transfers are considered for application on linen, this is best accomplished through the use of a hot iron.

Frequently stencils are applied by spray methods; here the stencil is cut of oiled paper, cardboard, or sheet lead. The colors are sprayed into and over the stencil using low air pressure. A four pronged tool is used to hold the stencil rigid while spraying.

### **Spraying Lacquer Direct from the Drum**

The advent of light gauge shipping containers being sold with the material it contains, has flooded the market with such shipping containers. Lacquer manufacturers will frequently use these lightweight non-returnable drums to ship clear wood lacquers and such low viscosity and lightweight materials.

Many lacquer users (especially furniture manufacturers) spray directly from the drum. This is very dangerous practice as the drums are not required to withstand the internal pressure that would be required to spray lacquers. This not only holds true of light gauge drums, but the heavier variety as well. Regulators are not satisfactory

in view of the many factors that would influence them to clog and cause the drum to burst.

Pressure feed tanks and gravity feed tanks have met with success wherever they are used, and this practice is recommended.

If spraying directly from the drum is to be carried out, it is suggested that the drum be elevated above the spray booth or in some conveniently located spot and attached on a gravity feed container hookup.

### **The Use of Shellac under Lacquer**

In former years it was common practice to use shellac underneath finishing coats and as a finish coat. This has been replaced with nitrocellulose lacquers, and such products are known as sanding lacquer undercoats or sanding sealers. Its use is strongly heralded wherever furniture finishing is conducted.

Any finishing material is considered durable only for that period that "life" remains in the film. In order to produce longevity of such life it is of vital importance that a film foundation coat resist the elements and have satisfactory cohesion with such materials as may constitute a finish. Shellac as used is "cut"  $3\frac{1}{2}$  or 4 pounds to the gallon of alcohol. Shellac is used mostly as a "wash coat" and to seal down the paste wood filler, stiffening such wood fibres as present and act as a foundation base for succeeding applications of clear wood lacquer. The alcohol used to dissolve the shellac is frequently a solvent for the paste wood filler. The pores of wood are usually quite deep and when shellac is applied, the alcohol resoftens the paste wood filler. This action tends to captivate the alcohol and when further applications of lacquer are applied, the volatile solvent again penetrates the shellac film, with the usual result that the captivated solvent in the pores of the wood that is collected in the natural air pockets will liberate the gas (solvent and air) which rises through the clear lacquer surface and forms air bubbles on the finished surface. The modern version of lacquer sealers, being basic nitrocellulose products, eliminate this objectionable feature. Such sealers are constructed along known and proven lines and have all the desirable features of a satisfactory base coat. The white powder sanding feature is present to act as an indicator for sanding.

### **Design and Arrangement of the Finishing Room**

The location of the finishing room should be such that fire hazards may be reduced and controlled. Fumes from any dipping tanks should be controlled to eliminate being carried by ventilating drafts to departments where fire is exposed.

The unnecessary handling of furniture should be avoided. Progressive spraying and drying should be considered.

Well-lighted rooms are essential to good work. The interior should be painted white or light colors. The room should be constructed so as to be easily changed in size. In some instances drop curtains are used in order to minimize the dust hazard.

Heat and humidity are important. Heating pipes should be placed along the walls rather than from the ceiling. Heat should be well distributed and controlled to raise and hold the temperature. Wet and dry bulb thermometers should be conveniently located to check the humidity. Maintained humidity (moisture, etc.) is essential for the character of the drying operation. Controlled air circulation is also important, especially when considering paste wood filler drying feature and furniture "in the white." Electric fans are used to create and maintain air movement in certain establishments as well as adjustable air vents. Carrier Air Conditioning System is also used to good advantage. Humidifying fans are placed in each drying compartment. These may be operated with or without the humidifying feature in operation and are governed in accordance with weather conditions.

It has been estimated that about 3% of the total cost of a piece of furniture is spent on the finishing materials that are used. The average furniture manufacturer will admit that the greatest percentage of complaints will concern the finish (as great a percentage as 90% of complaints is estimated to relate to the finish). It is the item on which the least money is spent that causes the greatest trouble.

Allied with well-balanced and carefully manufactured finishing materials is the proper treatment and care of the surface on which it is applied, both before and after coating.

### **Tests as Applied to Furniture Finishes**

In cabinet finishing, where for practical purposes, thin veneers are employed, close control of materials and finishing technique

should be inaugurated. The demands of industry in recent years which prompted the general adoption and use of quick drying lacquer coatings, indicated lack of such control.

Test values are usually determined on panels of standard size and type, and more than one panel is usually involved in the tests which follow:

### Preparation of Veneer Panels

In the preparation of veneer paneling, core, crossbanding, back and face veneer are involved. The veneer core is generally of gum, chestnut, or poplar wood of one piece stock, tight cut and free from loose knots or similar defects which may cause loose veneer or blisters. The crossbanding, usually constructed of gum or poplar, is generally one piece stock clear of splits. The back is preferably of gum and may comprise one or more pieces with minor defects permitted. The face veneer which at its best is quite thin, is further subjected to sanding, therefore its anchorage to the crossbanding should be very tight. A sufficient amount of the proper type of glue should be used and pressure throughout the entire panel so that a surface free of bulging is produced. Animal glue is preferred as an adhesive and the jelly strength, viscosity, odor and keeping quality, form test, acidity or alkalinity, moisture content, water absorption and strength test should be predetermined. Synthetic glues are gaining in popularity and are used in certain cabinet construction.

A five ply panel  $7\frac{1}{2}'' \times 12'' \times \frac{5}{16}''$  thick should be used; core of chestnut, crossbanding of gum, face veneer of quartered sliced straight grain walnut, and back veneer of gumwood. All face veneer should, wherever possible, be taken from the same flitch. The moisture content of the ply panel should be within the limitation of 4% to 6%. For this work vegetable glue may be used; however, animal glue or synthetic (tego) glue is preferred, which should have some bearing on giving much better results from the standpoint of warpage, especially as regards moisture test and/or temperature change test investigation. The face veneer should be  $\frac{1}{16}$  inch thick.

Once a determination of the moisture content has been made, the panel (face veneer) should be dry sanded using 4-0 garnet paper in which the sanding is "with the grain." The ends of the panel

should be cross-sanded at both ends. Dust should be free of the pores before staining.

A non-grain-raising stain which has been thoroughly mixed is used. Low air pressure (15–20 pounds on the gun) should be used and panel coated in an even application “with the grain of the wood.”

The stain should be permitted to air-dry for one hour in an atmospheric temperature of 70°F, wherever possible air drafts should be avoided.

The paste wood filler operation follows after the one hour dry of the stain. Filler, which is of the quick drying type, is first reduced with V. M. & P. naphtha (Sunoco spirits or  $\frac{1}{2}$  Sunoco spirits and  $\frac{1}{2}$  V. M. & P. naphtha may be used if conditions indicate) to approximately a 12 pound cut and brushed into the pores (across the grain). The filler is permitted to stand for several minutes, or until a flat condition indicative of early drying stage of evaporation starts, whence the excess is padded in, then wiped from the veneer across the grain. A clean-up rag is passed over the surface lightly to insure freedom from streaks. If the panel is extra porous, a double fill is considered necessary, repeating the operation above. If proper sanding in the white is resorted to, double filling should be unnecessary. The filler should air-dry for an overnight period in the confines of room temperature (70°F). If the relative humidity varies, the drying time should be in accord.

Sealer application is at 45 pounds air pressure on the gun and should be applied as a full and wet application. This should air-dry for one hour (room temperature of 70°F) and then dry sand with 5/0–8/0 garnet paper. The operation should, wherever possible, be in direct relation to the grain. This should then be detailed using 4/0 steel wool or 320 to 400 wet or dry paper, sanded dry. Sealer dust should be free of the surface before the next operation.

The first coat of clear lacquer should be sprayed as above, applying a full wet coat. This is given an air-dry of one hour and followed by a second full wet coat as above. This application should air-dry overnight (16 hour minimum) followed by the third wet coat which should air-dry overnight (16 hour minimum). A slight dry scuffing with 320 paper after the second coat will give a smooth finish, although it is not necessary.

Following the drying of the lacquer applications, a wet sanding with 380-400 paper and a suitable lubricant is given the panels. The sanding should eliminate any "gloss spots." Immediately following is the rubbing operation, which is a hand operation with a felt pad (padded soft rags will answer the purpose), using a good grade of rubbing compound. All uneven surface conditions, scratch marks, etc., are eliminated and following this, the surface is polished with a soft cloth, using a good grade of furniture polish.

Panels which are intended for the temperature change test value are then protected with gloss lacquer on the sides, edges and back. The panels are permitted to air-dry at room temperature for a minimum of 16 hours after polishing and before testing.

Most of the test values which follow are described under **TESTS**, Part III, Chapter IX.

The **APPLICATION** of finishing materials is determined physically by noting the manner in which it may level, etc. Reduction should be unnecessary.

**SANDING OF THE SEALER** is determined by its ability to cut clean and "powder" reasonably well. It must not "gum" the sandpaper.

**RUBBING AND POLISHING** is evaluated by the ease with which it is attained.

**CLARITY** of a three coat lacquer film is determined by observing the grain of the wood through the film. It must not show a haze or "cloud effect." The panel may be tilted to an angle whereby a lighted electric light bulb may be clearly reflected. The color of wet lacquer may be predetermined in a standard colorimeter or in standard test tubes.

**BUILDING** or fullness is determined by observing in the same manner as clarity. Three coats of lacquer over a properly filled walnut panel should show good building as determined by normal production applications. The percentage rating for this value has bearing on film fullness — without shrinkage.

**PRINT RESISTANCE** is an important value and one on which there should be placed a high percentage in a per cent value system. The film is given sixteen to eighteen hours additional drying after polishing before the test is run. The test is described under **TESTS**, although there are many variations which may serve the purpose equally as



well. Evidence of printing under a definite weight should give a value of zero for this test.

**HEAT RESISTANCE** — While heat values in lacquer systems as applied to wood does not have the relative importance of printing, moisture resistance, etc., it is of some concern since furniture may be placed near heaters, etc. The test is run in an oven at 150°F for a period of eight hours. Lacquer system should not show blisters and should show a minimum of shrinkage which would appear parallel to the grain of the wood.

**MOISTURE RESISTANCE** — The test involves a combination of pressure and moisture. The panel involved in the heat test may be used since it is necessary to have a coated panel which has been subjected to the action of heat. Two panels are used in this test, coated sides facing each other. Between these panels there is placed a water saturated felt pad. A weight is then placed on the top panel and permitted to remain for a period of twelve hours. Test is made for discoloration, film ruptures, and raising of the grain.

**TOUGHNESS — ADHESION** — There are many manners of determining this value, the rule of the stronger thumb nail predominating. A crisscross test as described under TESTS may be used.

**SOLVENT RESISTANCE** — This test is determined by making wells of putty on the flat film and placing alcohol of various spirit proof, water and liquids used to act as lubricants in the rubbing operation and the thinner used to reduce the paste wood filler. They are permitted to evaporate or remain for a twelve hour period at which time they are examined for softening.

**TEMPERATURE CHANGE TEST (COLD CHECK TEST)** — This important test consists of a cycle of alternate heating for one hour at 120°F and chilling for one hour at -5°F. The panels are placed in a vertical position when entering the heating unit, which is maintained by rheostatic control. At the end of one hour, panels are taken from the oven and *without interruption* are placed in a refrigerator unit in the same vertical position for a period of one hour. The refrigerator temperature should be controlled at -5°F during the period of this cycle. The hour each in the oven and refrigerator constitutes one cycle. As many test cycles as possible should be conducted in the space of a laboratory working day (eight hours). The panels for film rup-

tures are examined at the end of each cycle. A well-compounded lacquer should withstand 8 cycles, giving it a percentage value of 16.

Film ruptures which result from temperature changes will appear as checking of the finish. Care should be used in the examination of the panels for these ruptures, especially in the earlier cycles. They are more likely to be observed if the panel is placed about 15 degrees from the horizontal and with the source of light at the observer's back.

As a means of evaluating a wood finish, the following percentage rating is suggested; the second column indicating a material which should be satisfactory:

|                             | %           | %          |
|-----------------------------|-------------|------------|
| Application .....           | 5.00        | 4.00       |
| Sanding of the sealer ..... | 7.00        | 5.00       |
| Rubbing and polishing ..... | 10.00       | 7.00       |
| Clarity of film .....       | 4.00        | 4.00       |
| Building qualities .....    | 7.00        | 7.00       |
| Print resistance .....      | 15.00       | 15.00      |
| Temperature change .....    | 20.00       | 16.00      |
| Heat resistance .....       | 7.00        | 4.00       |
| Moisture resistance .....   | 10.00       | 8.00       |
| Adhesion-toughness .....    | 10.00       | 7.00       |
| Solvent resistance .....    | 5.00        | 3.00       |
|                             | <u>100%</u> | <u>80%</u> |

Since there is no perfect finishing material under variances of application, handling, etc., the figure (80%) will indicate a material practical and satisfactory for lacquer protective coating in consideration of the various tests.

It will be observed that a great consideration is given temperature change (cold check test) and print resistance test. These are the desirable attributes of a coating and it is the author's idea that a universal rating of investigation should be adopted and furnished to users of coating materials.

### Reclamation of Sprayed Lacquer

The woodworking industry presents the greatest possibility where waste spray lacquers may be reclaimed, fortified, and used again as a protective and decorative coating. In the furniture industry, where

lacquer sealers, clears and flats may be used, all sludge or spray residue which may be collected is intermixable and may be used as a further coating.

The water wash spray booth, centrifugal type, as described in Part IV, Chapter XI, is employed. The spray dust is collected, dried free of all moisture, fortified with plasticiser, etc., and reused.

## MOTOR CAR FINISHING

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While lacquer finishes were first used in production on automobile surfaces in 1923, today practically every manufacturer of motor cars uses lacquer in one or more processes of finishing.

A large part of the production of lacquers in the United States is absorbed by the automotive industry. Illustrating the growth of the lacquer industry since 1923, it is noted that in 1924 there were produced 3,590,000 gallons of automobile lacquer; in 1925, 11,000,000 gallons; in 1926, 22,000,000 gallons; in 1927, 30,000,000 gallons, while in 1928 no less than 47,500,000 gallons were produced.

The contribution of lacquer finishes as a solution to the problems of body building is emphasized to an increasing extent in working out improvements and refinements. Seventeen years ago when motor car manufacturers first seriously investigated nitrocellulose finishes and adopted them, such difficulties as odor, mechanical application, etc., encountered in actual application, almost condemned them before they could become a proven product. The quick drying feature of lacquer, as compared with the lengthy, drawn-out schedule involved in coating with color varnish, was perhaps the outstanding reason for the desire of further investigation.

Nitrocellulose lacquers had been used to a limited extent in the metal industry prior to 1923 and in view of their use, were considered quite adaptable. These products were used mostly as a protective coating on polished metallic surfaces where expansion and contraction of the film and such characteristics as may influence durability

were not considered. With the knowledge of the limitations of raw materials of that day, manufacturers of these basic ingredients set about to develop and improve new raw materials which laid the foundation of the present type of automotive lacquer finishes.

In the logical development of raw materials, synthetic resinous compounds came into being. Gum resins of fossil nature were used in the early type of lacquers to produce adhesion, gloss and add "body" or solids on the work. Such manufactured lacquers were of limited durability. With the perfection of synthetic resins as regards compatibility with nitrocellulose, fossil gum resins were replaced and the durability of automotive lacquers markedly increased. Lacquers which involved fossil gum resins were only subjected to very low "heat treatments" in order to hasten evaporation. Automotive lacquer formulation today contains large amounts of synthetic resins (6 to 8 to 1 of nitrocellulose) which permits of a much higher "heat treatment" and which has a direct bearing on the durability phase.

Synthetic enamels which require baking temperatures of 250°F to 300°F are used in automotive finishes today. The trend is definitely toward a baked synthetic finish.

### Preparation of the Surface for Lacquering

The ineffective cleaning and preparation of the surface to receive lacquer applications is said to be responsible for 90 per cent of lacquer faults and failures. In the earlier days with no cleaning, or rather inadequate and imperfect cleaning, coating failures were frequently encountered; so much so that the future of the steel body was despaired of. Perhaps the most serious offender was rust.

The preparation of the metal is regarded as a cleaning operation. It is important that all rust, scale, grease and foreign material of all kinds be thoroughly removed before coating applications are applied. (See FAULTS AND CORRECTIONS, Part III, Chapter X.)

As the auto bodies, in their course "down the production line," are received from the stamping assembly, the following operations are involved, preliminary to the coating applications:

- (1) Hand brushed with a solvent cleaner to cut the heavy grease.  
(See illustration No. 87.)

- (2) A warm spray follows the hand brushing which warms the metal so the chemical cleaner will work more effectively.
- (3) Chemical cleaner wash, such as deoxidine, is next applied by fixed spray application directed under high pressure. The chemical solution is collected and reclaimed.
- (4) The next application involves a cold water rinse to neutralize any of the chemical cleaner that may remain.



FIG. 87. Cleaning motor car surfaces

*Products Finishing*

- (5) A hot water spray is next and, after emerging from this operation, the bodies are blown with air under high pressure. (See illustration No. 88.)
- (6) The bodies are then routed through a drying oven (temperature of 200°F) to insure the thorough removal of moisture.
- (7) Emerging from this operation and, after gaining room temperature, the bodies are wiped with alcohol saturated cloths. (See illustration No. 89.) The surface is considered chemically clean and ready to receive coating applications at this point.

As the sheet metal parts, namely: hoods, fenders, etc., are received from the stamping department, they are hand scoured and then passed

through a washing and drying machine which involves the use of a chemical cleaner. An oven is a part of the washing machine and after passing through the washing operation, these parts are passed into



FIG. 88. Washing motor car surfaces

*Products Finishing*

the oven — on a conveyor — at 500° F. Leaving the oven, they pass through a cooling tunnel. Out of the tunnel, they are inspected and



FIG. 89. Alcohol wiping

*Products Finishing*

all remaining traces of grease and rust are hand cleaned and sanded (with wire brush if necessary) with a solvent cleaner.

Assurance that the surface is thoroughly clean is unquestionably

of great importance, as well as the prevention of rusting after lacquers have been applied. For this reason, the chemical cleaner employed should be effective and remove all visible particles which may develop into rust formations at a later date.

### Undercoats: Primers — Surfacer

The primer and surfacer operations follow immediately after operation No. 7 above. This is a very important operation of motor car finishing and on this foundation coating, rests the responsibility as regards durability of succeeding lacquer finishes. The selection of



FIG. 90. Flash primers

*Products Finishing*

such undercoatings indicates the use of materials which will expand and contract. High-bake oil-type and synthetic (oil modified alkyds) pigmented primers are used.

A coat of flash primer is applied by spray over the entire body surface. (See illustration No. 90.) This operation is enacted in a water wash spray booth as described in Part IV, Chapter XI, and the spray residue is recovered and reclaimed. This primer coat is of the quick setting type and is followed by a spray coating or surfacer. After the surfacer application, the body is routed through a baking oven and baked at temperatures ranging from 180°F to 220°F for periods of two to four hours. The bodies, after retaining room temperature, are



inspected for scratches, dents, etc. (See illustration No. 91.) The defects are chalk marked, the body is removed from the line and

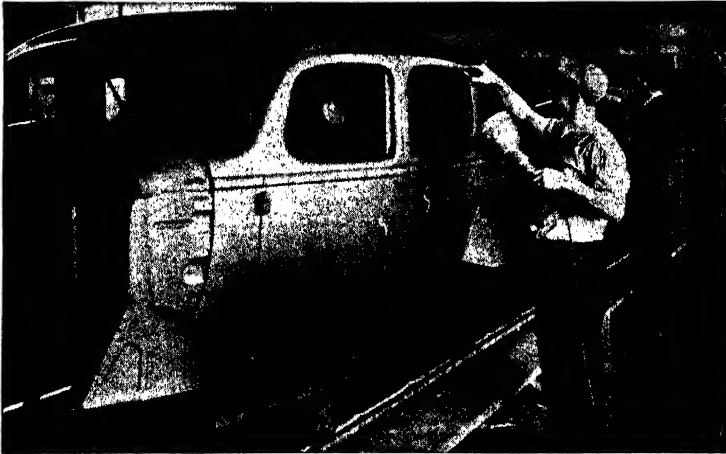


FIG. 91. Inspection

*Products Finishing*

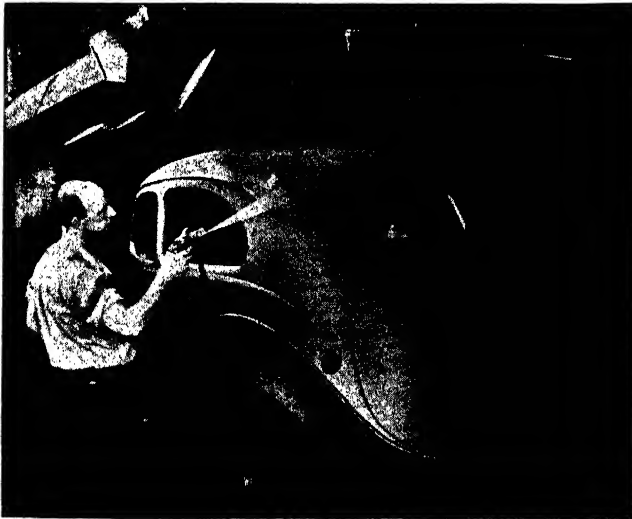


FIG. 92. Surfacers

*Products Finishing*

repairs are made. The second coat of surfacer is applied (see illustration No. 92) and the bodies are baked at 200°F for two hours. Fol-

lowing this baking, the bodies are carefully inspected and spot glazing is applied if the condition of the surface warrants such an operation.



FIG. 93. Spot glaze

*Products Finishing*

(See illustration No. 93.) Spot glaze applications are baked on the surfacer schedule. The next operation is the wet sanding of the sur-



FIG. 94. Wet sanding

*Products Finishing*

facier; 280 wet or dry sandpaper is used and water is the lubricant. (See illustration No. 94.) Following the wet sanding, the body is

flushed with water and wiped clean with a sponge. The bodies are then passed through an oven at 200°F for one hour in order to remove the last traces of any water that may be present. Bodies are then tack-ragged to remove any dust and are then ready for lacquer enamel applications.

### Bonderizing

This is a process whereby steel parts are passed through a water solution of manganese and iron phosphates at 210°F. Bonderizing is usually applied to sheet metal parts: hoods, fenders, etc. As mentioned earlier, these parts are thoroughly cleaned before bonderizing, which is customarily applied by the dipping process. The parts are placed on an overhead conveyor line, passed into the bonderizing tank and then through a baking oven at 450°F to 500°F. Out of the oven they are conveyed to an enameling tank where the enamel coating is applied by dipping (especially in the case of fenders). Two coats are customarily applied.



FIG. 95. Finishing booth

### Lacquer Finishing Coats

As the bodies enter the spraying tunnel, lacquer enamel is applied. Four spray men are located in this booth and the first two men each spray one half of the body as it passes. The second two men, who are located about 30 or 40 feet in the tunnel, each spray one half of the body as it passes. This double application constitutes the first application. A typical lacquer finishing booth is illustrated. (See illustration No. 95.) After this first coat of lacquer, the body passes on down the line where it is per-

mitted to air-dry (as it travels on the line) and a second coat is applied. This is a duplication of the first application (that is, it is a



FIG. 96. Polishing

*Products Finishing*

single cover-all application). The body then passes on for a period of ten minutes at which point it receives the third application (similar



FIG. 97. Striping

*Products Finishing*

to the second application). The bodies are then placed in a drying oven, where they are force-dried for about thirty minutes; tempera-

ture being 180°F to 200°F. After the bodies have maintained room temperature after force-drying, the inside of the body is sealed with waterproof compound and the bodies are passed on to be sanded and polished. In sanding the dried lacquer coats, Nos. 320–400 wet or dry sandpaper is used and water or soap solution as a lubricant. (See illustration No. 96.) Strong mercury vapor lamps are used in this operation to provide good illumination. Following the hand sanding,



FIG. 98. Final inspection

*Products Finishing*

the body is sponge rinsed with cold water and then blown with air to remove any water. The bodies are then polished, using standard preparations. Flexible polishing wheels employing sheepskin discs are used. After polishing, tack rags are passed over the surface to remove any dust and the final operation of striping is applied. (See illustration No. 97.) Following the striping operation, the body is inspected and if found satisfactory, is passed on to the assembly line. (See illustration No. 98.)

The operations which would have been enacted in 1927 are as follows:

- (1) Clean metal.
- (2) Dry sand.

- (3) Wash with lacquer thinner.
- (4) Moldings torched with a blow torch.
- (5) Bake at 180° F for twenty minutes.
- (6) Apply primer (oil type) and bake at 180° F for four and one half hours.
- (7) Apply spot putty.
- (8) Apply spot glaze coat.
- (9) Bake at 180° F for two hours.
- (10) Spray surfacer (oil type).
- (11) Bake at 180° F for two hours.
- (12) Spray a light sanding guide coat.
- (13) Bake at 180° F for two hours.
- (14) Sand.
- (15) Inspect.
- (16) Apply spot putty.
- (17) Bake at 180° F for fifteen minutes.
- (18) Sand.
- (19) Tack rag.
- (20) Apply ground color coat in Japan.
- (21) Bake at 180° F for two hours.
- (22) Sand lightly.
- (23) Tack rag.
- (24) Apply two single coats of lacquer.
- (25) Force-dry for fifteen minutes at 130° F.
- (26) Apply two single coats of lacquer.
- (27) Force-dry for thirty minutes at 130° F.
- (28) Water sand.
- (29) Blow dry with air and force-dry for fifteen minutes at 130° F.
- (30) Tack rag.
- (31) Polish.
- (32) Stripe.

### Lacquer Circulating System

Lacquer handling costs have been reduced and output increased by handling large volume finishing operations through the circulating system for spray finishing materials. The delivery of clean, fresh, uniformly mixed materials through pipe lines to the spray guns

makes for better working conditions. It eliminates the trucking of lacquer through the plant, prevents any mess around spray booths, makes possible a greater degree of plant cleanliness and reduces the fire hazard. There are no containers to clutter up the booth or to be

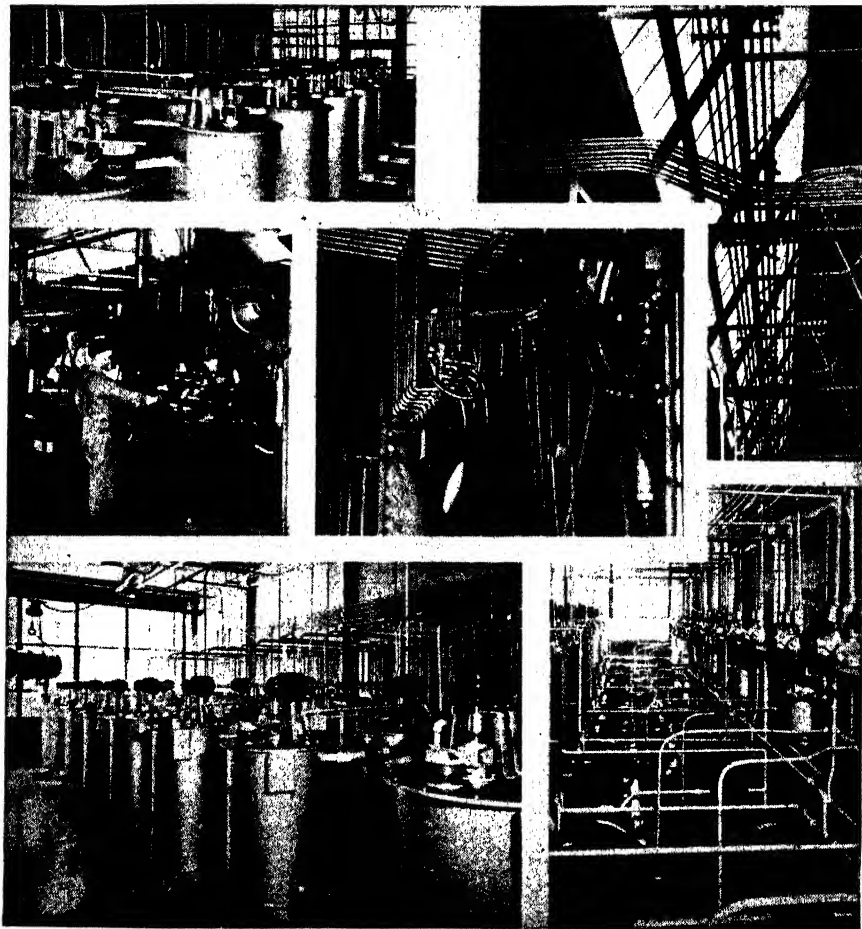


FIG. 99. Lacquer distributing system

*DeVilbiss Co.*

cleaned and refilled. Finishing material is delivered to spray guns at a uniform pressure, insuring even application in the proper thickness by each spray operator, thus lessening sanding and polishing operations.

Each pipe line carries a different color or kind of material. The finishing material for the paint supply lines is put into mixing tanks and thoroughly mixed by a motor driven agitator. It is then drawn from the tanks through pumps, strained and is circulated constantly from the mixing room direct to spray operators and returned to the mixing room. Regulated paint (lacquer) outlets are provided at the various spraying locations. (See illustration No. 99.)

In the manufacture of lacquer enamels for outdoor use, all raw materials should be selected with the greatest of care. Solvents and plasticisers should be chemically pure, resins should be proportioned in consideration of the great degree of expansion and contraction to which the steel body is subjected (flexibility is desired), and pigment matter should be carefully considered in view of fading, etc. In the manufacture, the ratio of pigment to vehicle should be considered and pigment properly dispersed and clarified before it is filled into containers. Care should be given the reduction of such enamels and only thinners which are compatible should be employed.

There are numerous motor car difficulties which are described under FAULTS AND CORRECTIONS.

### Bus Finishing

The present trend in bus, truck, and street car construction involves lightweight metals. Aluminum and its alloys are employed to a large extent. The use of such metals created new finishing problems, such as finish ruptures at the rivet heads and joints. This exposure of the metal caused aluminum oxide to form, pitting of the metal, and rusting. High solids synthetic lacquer is used and will withstand vibration stresses set up by the weaving action of the bus or street car. Such a lacquer film, in addition to containing high solids, will retain its lustre over a longer period, will give increased coverage per gallon over conventional lacquers and will withstand temperature changes more readily.

The aluminum or its alloy should be treated with an acid etching, (deoxidine) washed with hot water to thoroughly free the acid, washed with lacquer cleaner, blown with air and *immediately followed by a primer coating.*

A zinc chromate synthetic primer is used and sprayed very lightly



over the entire surface. The metal should in no case be completely covered by this yellow coating. This primer coat is air-dried for six to eight hours and followed by the surfacer coat. Two coats are applied in one continuous operation and air-dried for six to eight hours, at which time it is water sanded. Following this, air is blown over the entire surface to remove lasting traces of water. A light coat of synthetic lacquer is next applied and followed by a full wet coat. The third and final coat is also applied as a full wet coat. A mist coat may then be applied over the lacquer or it may be rubbed and polished.

Synthetic enamels may be substituted in this system for the synthetic lacquer. Except for the substitution, all materials and procedures are identical. Whichever system is used, the greatest of care should be exercised between the final cleaning and application of the chromate primer. Handling and finger marks should be avoided.

### **Flow-Coating Lacquers**

The use of floco-lacquers in automotive establishments has been attempted but has met with little success. Their use has been retarded due to their rapid evaporation, as well as the biting action of the solvent structure on the previous coatings. The synthetic lacquer or synthetic enamel systems as coatings show great possibilities. Such systems which will remain "wet" longer, permit heat treating or baking, and in the event sagging occurs, may be sanded and rebaked whereby the sand markings will blend together.

### **Refinishing Motor Car Surfaces**

Refinish jobs are classified as:

- (1) Burn-off and refinish.
- (2) Resurface and refinish.
- (3) Refinish without surfacing.
- (4) Quick touch-up and refinish.

The first type, "burn-off and refinish jobs," is the highest quality. This consists of completely removing all traces of the old finish down to the metal. The car is placed on a cleaning rack where dirt, grease, etc., are freed from the surface. Steam and solvent solutions (patented process), paint and varnish or baked enamel removers may be used.

Any wax remaining on the surface should be cleaned with lacquer cleaner. Air-drying undercoats (primer and/or surfacer) are customarily used or these coatings may be baked. If air-dried, at least twenty-four hours should be required. The finishing procedure is much the same as described above.

A resurface and refinish job is steam cleaned and sanded with gasoline. A combination primer and surfacer is applied and air-dried for twenty-four hours. The job is sanded and synthetic lacquer is applied, rubbed, and polished.

Refinishing without surfacing involves a job in which the surface lacquer is in good condition, but the color may have faded, etc. Any slight surface imperfections are glazed, sanded and synthetic lacquer is applied to a finish.

A quick touch-up and refinish job is much the same as refinishing without surfacing, except that a minimum number of lacquer coats is applied.

### Lighting Facilities

In order to secure a satisfactory finish, it is essential that all surface defects be made visible to the workman. It has now been well established that increased acuity gives quicker light, and sharpness of vision depends upon brightness and the kind of light. The light which enables the workman to turn out the most work will enable him to turn out the best work. Lighting is therefore an important item in automobile finishing where manufacturing conditions require a steady production flow. High intensity illumination utilizes every square foot of floor area for protection.

We see with the mind, therefore, the relationship of the quality of light to the defects of the eye lens, having bearing on the manner in which the particular spectrum of the light corrects the chromatic aberration of the eye produced by continuous spectra light, also has great bearing on the workman's ability to turn out the best work under very satisfactory conditions. All light from glowing solids is termed incandescent light, while the light emitted from glowing gases or vapors is termed luminescent light.

The light of luminescent mercury greatly reduces the range of wave length found in incandescent light, and stills the mind through the

eye by bending the rays of light and producing an image of perfect sharpness. Mercury light is the nearest approach to "cold light" produced. True daylight, or that period about one-half hour after sunrise to several hours after sunset is quite naturally the best light, producing ideal working conditions from a lighting standpoint. Such conditions as weather elements and indoor work should be considered. The constant intensity at any hour of the day of the Cooper-Hewitt light is therefore considered better than daylight. It is composed almost entirely of yellow-green (the best seeing rays of light), and has none of the glare-producing qualities which are irritating to the eyes.

The light unit comprises a fifty-inch glass tube containing a small amount of mercury, which under the action of electricity, vaporizes a small portion of this mercury which becomes luminous and develops a light free of red rays and a light of high visual acuity. This tube is covered with a metal reflector coated with white enamel. This reflector extends below the tube which reflects the light downward. Auxiliary containing coils and mercury switch are centrally located on the reflector and likewise serve as a support for both reflector and tube.

## PART V

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### CHAPTER XIV

#### GLOSSARY

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R. C. M.

**ABIETIC ACID.** The active ingredient in rosin which takes part in reactions in the varnish kettle. In recent years numerous compounds of great complexity have been isolated from turpentine and rosin and have found practical use in the industry. As a general term such compounds are referred to as "pine tree chemicals."

**ABRASIVE.** A substance used for wearing away a surface by friction. Pumice stone, rotten stone, charcoal, sandpaper and steel wool are some of the abrasives used for rubbing lacquer surfaces. (The opposite of lubricant.)

**ABSORB.** To swallow up, suck up, drink or suck in. A surface is said to be absorbent when it takes in to itself and holds the finishing material applied over it. Such surfaces are usually more or less porous. Absorption should carefully be distinguished from adsorption, which is the act of holding gases or dissolved substances on the surface of solid bodies by molecular attraction. For example, fuller's earth, when used for clarifying oils, absorbs some of the oil but the coloring matter is removed chiefly by adsorption, or the adhesion of the coloring matter to the surface of the particles of fuller's earth. See *Adsorb*.

**ACCELERATE.** To hasten or quicken the natural progress or process of an event or a series of events. For example, the drying of finishing materials is hastened or accelerated with an increase of temperature. An accelerated test of a finishing material is a severe test that determines the comparative durability in a shorter length of time than required under actual service conditions.

**ACCELERATED WEATHERING.** Machine made means of duplicating or reproducing weather conditions. See *Weatherometer*.

ACETAMIDE. ( $\text{CH}_3\text{CONH}_2$ ) A white crystalline powder form used as solvent/plasticiser in plastics.

ACETATE DOPE. A cellulose acetate lacquer solution used in coating aircraft fabric.

ACETATES. A group of organic solvents representing the combination of various alcohols with acetic acid. Acetates are solvents for nitrocellulose and are used to considerable extent in the manufacture of lacquers. See *Ethyl*, *Butyl*, *Methyl* and *Amyl Acetates* for further details.

ACETIC ACID. ( $\text{CH}_3\text{COOH}$ ) Peculiarly sharp odored clear liquid — present in dilute form in vinegar.

ACETONE. (Dimethyl Ketone —  $\text{CH}_3\text{CO.CH}_3$ ). A water-white volatile liquid with a peculiar ether-like odor and a burning taste. Made by the fermentation of butyl alcohol, by the destructive distillation of acetate of lime, and by the destructive distillation of hard woods. Acetone has an outlet in the manufacture of smokeless powder and to a certain extent in the manufacture of lacquers and paint and varnish remover.

ACETONE OIL. A by-product of acetone in the distillation of hard woods and consists of a mixture of ketones, etc.

ACID NUMBER. An expression of the amount of free acid in fats, oils, waxes and resins, expressed as the number of milligrams of potassium hydroxide (KOH) required to neutralize one gram of the material being tested.

ACID REFINED LINSEED OIL. Linseed oil treated to remove mucilaginous matter.

ACID RESISTING. This expression is usually referred to in connection with a dried film of coating material showing no hazardous effects upon subjection to or with acids.

ACID STAIN. Stains or dyes of an acid nature or those which depend upon an acid to set them when dyeing cloth are called acid dyes or stains. Most of these are coal tar dyes and are water soluble. Water soluble stains are often called "acid stains."

ACID VALUE. See *Acid Number*.

ACROSS GRAIN. Not with the run of the grain. When sanding sealer or paste wood filler is ready for rubbing, they should be worked across the grain rather than with the grain.

ACTINIC RAYS. Those rays of light which cause chemical changes to take place in a lacquer film. The actinic rays of sunlight are strongest in July in the United States and weakest in January.

ADHESION. The act or state of adhering, or in more specific words, the sticking together of substances in contact with each other as though they were glued. Paint and varnish materials hang together principally by adhesion, although they also have some cohesive power to hold the individual particles together. Lacquers stick to the work mostly by cohesion, although they also usually have some adhesive powers.

Latin: ad and haereo (stick to). Methods have been proposed for measur-

ing the adhesion between solids and liquids, that is, their wettability. (Journal of Rheology.)

**ADSORB.** To hold on the surface of solid objects by a molecular attraction. See *Absorb*.

**ADULTERATE.** The act of substituting one substance in whole or part for another (usually of greater value).

**AFTER YELLOWING.** Many coating materials have a tendency to become yellow on exposure. This tendency is naturally more noticeable in the case of whites or of transparent finishes applied over a white or pale colored surface. Gardner states that circumstances which induce yellowing of one type of pigment may bleach other types, while the same pigments may reverse their behavior under a different set of conditions. Clear varnishes and lacquers, particularly those containing synthetic resins, may also yellow considerably.

**AGING.** A finishing material is said to age when it is allowed to stand for some time to improve the flowing, brushing or other qualities. For example, label varnish is allowed to stand or age, until the finely divided particles present have separated and settled to the bottom of the tank. Aging of such materials will vary and depends on the type and properties which it is desired to improve.

**AIR BRUSH.** See *Spray Gun*.

**AIR DRYING.** A lacquer coating material is said to be air drying when it is capable of drying hard at ordinary room temperatures and without the aid of artificial heat. Almost all nitrocellulose lacquers are of the air drying type.

**AIR LINE TROUBLES.** Troubles of this nature are usually the result of water or oil which is forced through the gun. Remedied by bleeding the line through a trap.

**ALCOHOL.** See *Grain, Denatured, Amyl, Butyl, Ethyl, Methyl, Wood Alcohol*, etc.

**ALCOHOL RESISTING.** This expression is usually referred to in connection with a dried film of coating material showing no hazardous effects upon subjection to/or with alcohols.

**ALCOHOL WATERED.** This condition oftentimes causes grayness in furniture finishes and may be due to high proof alcohol condensing moisture from the air.

**ALIPHATIC HYDROCARBONS.** The term includes comparables to coal tar products of solvent-like nature which are directly based from petroleum.

**ALIZARINE LAKE.** A very permanent bright red lake color with a blue undertone made from alizarine by a complicated process. One of the most widely used alizarine lakes is the modern madder lake. Such lake colors are generally speaking of transparent nature; for this reason sufficient opaque ground coats are necessarily applied underneath the lake color.

**ALKYD RESIN.** Synthetic resin of the glycerol phthalate type — basically an ester.

**ALLIGATORING.** A term describing the appearance of a lacquer film that is cracked into large segments, resembling the hide of an alligator. When the alligating is fine and incomplete, it is usually referred to as "checking."

Alligatoring may be caused by heavy coats on unseasoned wood, by one coat being applied over another before the bottom coat is thoroughly hard and dry and/or by the lacquer film top drying so as to leave the lower portions of the film soft and elastic, or by a less elastic material being applied over a more elastic coating underneath.

When these conditions are present and the finished article is exposed to changes in temperature or moisture content, expansion or contraction takes place which cracks the hard outer crust while the softer underneath coating comes and goes without breaking. In the case of top drying materials, or of extra heavy coats, this cracking may take place without a change in temperature or moisture content, simply through the hardened outer crust being broken when the bottom portion dries, much as a bank of clay mud is cracked under the summer's sun. Such a condition may also be attributed to excessive air being forced onto a surface. Such excessive air pressure may be present by spray gun application of lacquer materials. The presence of too rapid evaporating thinners will also cause alligatoring. Also see *Cracking and Crazing*.

**ALUMINUM LEAF.** A thin leaf used for silver color on the surface of wood, stone and metal for lettering or decorating, where silver leaf would tarnish. Chiefly manufactured in Germany. Usually  $5\frac{1}{2}$  inches square and packed in books of 25 leaves each, 20 books to a "pack." Also comes in rolls 67 feet long by any width up to 5 inches.

**ALUMINUM PALMITATE.** A material sometimes used variously as a flattening agent, as a weatherproofing compound, or as a bodying agent when added in comparatively small amounts to lacquer products.

**ALUMINUM SILICATE.** A white inert pigment of little color and opacity. Obtained from certain natural deposits of china clay, kaolin, feldspar and similar materials.

**ALUMINUM STEARATE.** A pure white powder, the manufacture of which belongs to soap making. Used to prevent settling in paints.

**AMBER.** A yellowish translucent gum resin formerly used to some extent in the manufacture of varnish. No longer used in commercial quantities because of scarcity. This term is also used to refer to the color of a clear lacquer. An amber color is one which has a yellowish, clear, translucent appearance; in other words, it resembles the color of amber.

**AMARANTH RED LAKE.** A purple tone red lake pigment made by precipitating an extract of various woods on a metallic base. When used as a finishing lacquer, this lake color requires the use of an opaque ground coat.

**AMORPHOUS.** Without regular or definite crystalline form. Gas black, Prussian blue and similar pigments are amorphous.

**AMYL ACETATE.** ( $\text{CH}_3\text{COOC}_5\text{H}_{11}$ ) An ester by the esterification of acetic acid with amyl alcohol. Solvent for nitrocellulose and used quite extensively in lacquers.

**AMYL ALCOHOL.** One of the higher alcohols which is present in fusel oil.

**AMYL LACTATE.** ( $\text{CH}_3\text{CHOHCOOC}_5\text{H}_{11}$ ) A water-white to pale yellow colored liquid used as an ester solvent and plasticiser in lacquers.

- AMYL STEARATE.** ( $C_{17}H_{35}COOC_6H_{11}$ ) A pale yellow colored liquid — used as a high boiling plasticiser in lacquers.
- ANHYDROUS.** A material is anhydrous when it is free from moisture.
- ANILINE COLORS.** Colors made from coal tar derivatives and greatly used in the manufacture of wood stains. Some aniline colors are soluble in water, some in coal tar solvents and others in alcohol; and accordingly are sometimes called water colors, oil colors and spirit colors respectively.
- ANILINE OIL.** ( $C_6H_5NH_2$ ) A colorless oily liquid used in certain coating removers.
- ANSOL.** A blend of denatured ethyl alcohol with 6 per cent ethyl acetate, 3 per cent butyl acetate and 6 per cent benzol. Such additions of regular and latent solvents excite solvation on alcohol soluble nitrocellulose.
- ANTICORROSIVE.** Lacquer coatings applied on metallic surfaces which retard or prevent corrosion are said to be anticorrosive coatings. An anticorrosive paint is one constructed of neutral or slightly alkaline pigments to be used as a first coat on metal to prevent or retard corrosion. See *Inhibitor*.
- ANTIFOULING.** Lacquers are not used in conjunction with antifouling preparations. An antifouling paint is one which contains toxic or poisonous substances to prevent the growth of barnacles on the hull of ships or other objects submerged in water.
- ANTIMONY OXIDE.** ( $Sb_2O_3$ ) A pure white pigment of high opacity. When used in conjunction with lacquer or synthetic enamels, it is customary to use with Titanium Oxide for a pure white enamel.
- ANTIQUING.** When furniture or other finished objects are antiqued, certain parts are made to appear antiques through the application of stain or other colored materials to only those parts that are to be darker when the work is finished. The idea of the antiquing is to make certain parts of the object appear to have had more wear than other parts as would be natural with age. See *Highlighting* and *Glazing*.
- APPLICATION.** An application of finishing material is thought of as the act of going over the entire surface to be coated, only once. In other words, if a lacquer is being applied by spraying, when the operator has covered the entire surface without repetition he has made one application. If he immediately goes over the same work again he has made another application, although the two applications may be considered as only one coat if it is possible to make the second application without producing runs and sags and if the first application is not hard and dry at the time the second application is made. The principal methods of application are: Brushing, spraying, dipping, tumbling, stenciling, flowing, squeegeeing and offset printing. See *Full Coat*.
- AROCLOR.** A chlorinated diphenyl lacquer softener.
- AROMATIC HYDROCARBON.** Liquid solvents of coal tar; e.g., benzol, toluol, xylol and solvent naphtha.
- ARTIFICIAL RESIN.** Another term for synthetic resin — resin made by artificial means.
- ASBESTINE.** An inert pigment or extender, consisting of a fibrous variety of talc (magnesium silicate). Aids in preventing settling of pigments and adds strength to the dried film of lacquers. See *Magnesium Silicate*.



**ASPHALTUM.** A mineral-like material which is mined much the same as coal and has somewhat the same general appearance. It is soluble in oil, petroleum and coal tar hydrocarbons and many other solvents. Used to some extent in chassis black lacquers.

**BAKELITE.** A condensation product by the reaction of phenol with formaldehyde in the presence of certain other chemicals and under the proper conditions. It is in the nature of a resin and by controlling the process of manufacture the product can be produced in a soluble form which upon subsequent reaction becomes insoluble in practically all acids and other chemicals. The soluble forms of these so-called phenol resins are used in the manufacture of lacquers and quick drying varnishes and enamels.

**BAKING.** The process of drying a coating material by the application of artificial heat. A baking product is one which requires the application of artificial heat to become hard and dry. Lacquers are not baking products. The presence of a small amount of heat is sometimes used in production to hasten the evaporation by driving the volatile solvents from the film. Such methods are used in applying lacquers, especially in motor car production. See *Force Dry*.

**BAKING OVENS.** Ovens used to force dry or bake applied finishes. They may be gas fired, electricity or steam fired.

**BALANCED SOLVENTS.** In lacquer formulation, the exacting performance of a given product indicates proper ratio of liquids (solvents) to solids.

**BALL MILL.** A cylindrical metallic mill which employs steel balls inside the revolving cylinder, which as they fall against each other, and against the side of the cylinder, reduce the size of pigment particles present. Such mills are not lined.

**BALSAM.** The gummy mixture of resin and oil which exudes from wounds in soft wood trees such as pine, fir, etc.

**BANANA LIQUID.** An amyl acetate nitro-cellulose solution. So termed because of odor resemblance to over-ripe bananas.

**BANANA OIL.** A bronzing liquid containing amyl acetate. Also see *Amyl Acetate*.

**BAR FINISH.** A hard, yet flexible lacquer finish used on hardwood bar tops.

**BARIUM SULPHATE.** ( $\text{BaSO}_4$ ) White pigment used in paint manufacture. See *Barytes* and *Blanc fixe*.

**BARYTES.** One of the inert pigments which is prepared by grinding under water the crude mineral barite which is found in different sections of the U. S. It is unaffected by acids and alkalis but has no opacity and is used either as a base for other colors or as a bodying medium or extender. Barytes is practically pure barium sulphate.

**BASE.** The metallic salt upon which coloring matter is precipitated to form the insoluble pigments, called lakes. A paste or liquid which is to be thinned or tinted is also called a base.

**BASIC.** Of an alkaline nature. Capable of uniting with an acid to form a salt. Of the base.

**BATAVIA DAMMAR.** That grade of dammar gum or resin which has its source in Batavia, Java. Batavia dammar has two sub-grades, according to the district from which it is secured. Padang Batavia dammar and Sumatra Batavia dammar. It is claimed by some that Batavia dammar is better than Singapore dammar; others say there is little or no difference.

**BAUMÉ.** The name of a hydrometer scale used for taking the relative weight of finishing materials as well as many other liquids, as compared to the weight of an equal volume of a standard liquid. There are two Baumé scales—one for liquids lighter than water, the other for liquids heavier than water. The standard liquid used for constructing the Baumé scale for liquids lighter than water is a mixture of one part salt to nine parts of water. The distance to which a hydrometer sinks in pure water is taken as 10 on the lighter than water scale. The zero point on the scale is the point to which the hydrometer sinks in the 9 to 1 salt solution. The distance between the two points is then divided into ten equal parts and these same spacings are then made on the spindle above the 10 mark up as high as may be required for the liquid in which the hydrometer is most frequently used.

For liquids heavier than water the Baumé scale is constructed as follows: The point to which the hydrometer sinks in pure water is marked zero. The point to which it sinks in a mixture of 85 parts of water and 15 parts of salt (by weight) is marked 15. Between these two points the space is divided into 15 equal divisions and these same size spacings are added below the 15 mark to make a total scale of 0 to 70 degrees.

It will be seen from the above that the zero point on the heavier than water Baumé scale corresponds to the 10 degree point on the lighter than water scale. It is necessary to always mention which scale a Baumé reading is taken on in order to know the gravity of the material. The standard American Baumé system as defined by the Bureau of Standards has a definite relation to the specific gravity system as shown by the following formulae:

*Liquids Heavier Than Water*

$$\text{Deg. Bé.} = 145 - 145/\text{Sp. Gr.}$$

$$\text{Sp. Gr.} = 145/(145 - \text{Deg. Bé.})$$

*Liquids Lighter Than Water*

$$\text{Deg. Bé.} = (140/\text{Sp. Gr.}) - 130$$

$$\text{Sp. Gr.} = 140/(130 + \text{Deg. Bé.})$$

*Also see Hydrometer*

**BENDING TEST.** A test conducted on a metal surface and over a mandrel, the coating having been applied and the determination being the resistance of a coating to bending (rupturing).

**BENZENE.** A very light gravity coal tar distillate which is more commonly called "Benzol." Do not confuse the spelling of benzene with that of benzine, which is an entirely different product, derived from the distillation of petroleum oils. It is better, to avoid confusion, to use the benzol to designate the light gravity coal tar product.

- BENZINE.** A very light gravity petroleum distillate, less volatile than gasoline but ore so than kerosene. See *Naphtha*.
- BENZOL.** A by-product of the distillation of coal tar. It has great solvent properties for many of the materials used in the paint, varnish and lacquer industries. For this reason it is used very extensively in paint and varnish removers. Because of its toxic effect on many workers, benzol has been replaced by toluol and xylol in the manufacture of lacquers. See *Benzene*.
- BINDER.** The binder in a lacquer is that liquid portion which binds the pigment particles together after the material has become dried. Such products as plasticisers and nitrocellulose are usually referred to as binder.
- BITING.** When a coat of nitrocellulose lacquer material is applied over another coat of lacquer or similar finishing material the solvents in the top coat partially dissolve or bite or eat into the bottom coat. Lacquers are said to be less biting when they exert this softening action to a lesser extent on the underneath coats. If the solvents are too biting, the dried lacquer surface is sometimes quite rough or full of "orange peel" or "pebbled effect" as though the lacquer had not been finely divided when applied by spraying.
- BITTY.** When small bits of skin or partially hardened material is present in paint or varnish the material is said to be bitty. This is usually caused by the material standing for some time, partially exposed to the air. Such a condition is rarely ever referred to in conjunction with nitrocellulose lacquers.
- BITUMEN.** Any of the mineral pitches, or materials containing them, such as asphaltum, crude petroleum, coal, etc., are said to be bituminous.
- BITURINE.** Trade name of an asphaltum type paint material.
- BLACK LAKE.** "An iron lake of hematine, the dye of logwood" — Paint Varnish and Lacquer glossary by Donald Davidson.
- BLACKNESS.** A term used to describe the overtone of a black lacquer. The degree of blackness is determined by the degree of absorption of all light waves. A material which absorbs all light waves but certain ones of a blue cast is spoken of as blue-black, one which shows a grayish cast reflects certain waves which combined produce a gray color, etc.
- BLACK TONER.** A black pigment, usually consisting of either black lake, aniline black dye or purified bone black.
- BLANC FIXE.** An artificially prepared barium sulphate which is finer, more bulky and more opaque than barytes. A typical analysis is:

|                                              |     |
|----------------------------------------------|-----|
| Barium Sulphate .....                        | 98% |
| Barium Carbonate .....                       | 1%  |
| Silica, Silicates and other impurities ..... | 1%  |

**BLEACHING AGENTS.** Those materials which are used to unify or lighten the color of woods which are used in making furniture and similar objects are known as bleaching agents.

There are a number of satisfactory solutions for bleaching wood. Probably the best method of obtaining a uniform color is to first apply a solution of

potassium permanganate made by dissolving one ounce to the gallon of water. Apply this solution freely and while still wet apply a solution of sodium bisulphite made by dissolving two to four ounces to the gallon of hot water. The solution should be allowed to cool before using.

Another method of bleaching is to use the sodium bisulphite solution mentioned above without first using the permanganate solution, but this will not produce as uniform a color as where the two solutions are used in conjunction with each other. A solution of two to four ounces of sodium hypo-sulphite to a gallon of hot water will give results comparable to those obtained with sodium bisulphite; or if desired, hydrogen peroxide used full strength as obtained commercially can be used with success. Chloride of lime, or calcium hypochlorite, is a strong bleaching agent but it is seldom used for bleaching wood.

Any of the above solutions should be applied cold and not hot, putting them on quite freely by brushing or sponging. It is good practice to sponge off the work with clean water to remove any excess bleaching agent that may be present after the desired shade has been obtained. The work should be allowed to dry thoroughly after the application of the bleaching agent before proceeding with the finishing operation.

After the bleaching solution is thoroughly dry, a thin coat of lacquer should be applied. Shellac is sometimes used. This stiffens the fibre and seals the wood so as to prevent oil from the filler penetrating and darkening it. When this lacquer, or shellac coat, has been dried 5 hours or so, sand the work to a good surface. Sanding undercoats may also be used. After thoroughly dried the finishing operation may be carried out in the regular manner; i.e., filler, sealer, lacquer. If sanding undercoat is applied after bleaching operation be certain to apply a very thin coating.

**BLEACHING LACQUER.** Basic lacquers to which have been incorporated bleaching solutions; used for lighting effects on dark woods.

**BLEEDING.** When the color of a stain or other material works up into succeeding coats, imparting to them a certain amount of color, it is said to bleed. A non-bleeding color is one which is not soluble in materials used over it and consequently does not work up into succeeding coats. Certain shades of aniline oil colors will bleed through any number of finishing coats applied over it. This is often noticed in trying to apply a white lacquer over old mahogany work.

This term also describes the act of applying a thin coat of shellac or sanding sealer over a stain to bleed it or richen it.

**BLENDING.** The word "blending" is often used almost synonymously with the word mixing. That is, when two materials are blended together they are intimately mixed together. At other times blending refers more particularly to gradually shading off from one color to another, as for example: blending stains are those stains which are used to make certain parts of finished work to have a different or darker color than other parts and to make this change in color or depth of color take place gradually. Blending also describes the act of imperfectly mixing colors after application, as in graining.

**BLISTERING.** This term refers to the formation of bubbles, blisters or of pimples on the surface of the finished work, usually after the film is dry. Blistering is caused by exposure to excessive heat such as direct sun rays, by underlying spots of grease, by moisture in the wood, by improper filling of the pores of the wood, or by the too frequent application of coats which prevent the finishing material from drying thoroughly. Blistering may also be caused by finishing over wood that is slightly green or imperfectly dried. When such work gets warm upon standing in the sunlight or upon being dried in a kiln, the moisture comes out and causes blisters. A heavy coat of shellac over the filler may be at the bottom of blistering trouble in that it seals in moisture from the stain or unevaporated thinners in the filler, which expands upon exposure to a slightly higher temperature, and causes the shellac coat to blister. Vapor, gas or water is usually present in blisters.

**BLOOM OR BLOOMING.** A bluish cast which sometimes forms on the surface of a dried lacquer film. Certain atmospheric impurities such as vapors, smoke, ammonia fumes, illuminating gas, etc., sometimes cause blooming which is very similar to the dirt which collects on window panes from the same causes. Too much paraffin oil used on the floors of the finishing room or warehouse may give off vapors which condense on finished surfaces and cause blooming. In fact, any condition which allows a film of smoke, oil, dirt or some similar substance to form on the finished work is likely to result in blooming.

A bloom sometimes appears on clear lacquer work after it has been rubbed a short time, and in such cases may be caused by rubbing before the film is sufficiently dried; by rubbing with too much pressure; by the use of too coarse pumice stone; by the use of insufficient lubricant during rubbing; by the presence of small quantities of moisture and oil in the film due to oil and water in the spray line; by excessive humidity which prevents the film from drying thoroughly or by any set of conditions that would cause the scouring or deep scratching of the film before it becomes thoroughly hard and dry. One of the most frequent causes of blooming is the use of a rubbing oil which contains a sticky, greasy residue that cannot be wiped off clean.

Blooming should not be confused with blushing, which takes place before the film is dry, while blooming takes place after the film is apparently dry. To remove a bloom, first sponge off the work with lukewarm water and castile or some other neutral soap, then rinse thoroughly with clean water and wipe dry with a moist chamois. Sometimes on lacquer work where the blooming is extremely bad it is advisable to use a little 4F pumice stone or rotten stone with the soap and water. If necessary, go over the work after washing, with a good polish—one that does not leave a greasy film to catch dirt. See *Cloudiness*.

**BLOWN OIL.** Oils which have been bodied and partially polymerized or oxidized by blowing air through them are known as blown oils. Of this type blown castor oil is used frequently in lacquer manufacturing.

**BLUING.** A bluish overcast which sometimes forms on finished work. Practically synonymous with "blooming."

This term is used also to describe a decided blue or green cast, especially on black work; such as when a clear lacquer is applied over a black undercoat.

This may be avoided by tinting the last coat with a small amount of black. See *Greening*.

**BLUSHING.** When a lacquer film takes on a white or grayish cast during the drying period it is said to "blush." Blushing is caused directly by the precipitation of a portion of the solid content of the material, which gives an opaque appearance. Oil or water mixed with the film are common causes. Moisture and oil in the spray line or a high relative humidity in the atmosphere often cause blushing in the lacquer film. Direct draughts or insufficient ventilation are also occasional causes. The method by which blushing is caused by high humidity is as follows: The air is filled near the saturation point with water vapor. As the volatile materials in the film vaporize they absorb heat, thus cooling the film of air directly adjacent to the lacquer and causing it to deposit some of its moisture. This deposited moisture precipitates a small amount of nitrocellulose which is immediately redissolved, if there are sufficient solvents left in the film.

Eventually a point may be reached where there are not enough solvents for nitrocellulose left in the film to redissolve the precipitated nitrocellulose, whereupon the film remains permanently gray or white.

To prevent blushing keep the temperature of the room quite high and thus lower the relative humidity. Also use a small quantity of high boiling solvent such as amyl acetate or butyl propionate which will remain in the film until it is dry, thus redissolving the nitrocellulose as fast as it is precipitated. Small traces of moisture are always present in freshly applied lacquer films and unless the solvents used are of the type that have lower vapor pressures than water or that form evaporating mixtures with water, the film is likely to blush. Blushing may also be caused, aside from the presence of small traces of moisture, by the solvent combination becoming unbalanced by evaporation so that the non-solvents for nitrocellulose or for some other constituent of the lacquer become more concentrated and allow one or more of the constituents to be precipitated.

The use of thinners supplied by the manufacturer of the lacquer has bearing on the procurement of a more satisfactory film than thinners used and secured from a different source.

**BODIED OIL.** Oil (linseed) heated to about 500° F. with lead, cobalt and manganese oxides; now applied to oil in which the lead and manganese linoleates are dissolved regardless of the temperature employed.

**BODY.** A combination of viscosity and density of a lacquer, sometimes spoken of as its "consistency." To prevent confusion it is better to use the term "consistency" to describe this property of a lacquer material, as the "body" is sometimes used to designate the fullness or thickness of film on the work.

**BODYING ACTION.** A lacquer material is said to have a bodying action when it has a tendency to take on a thicker consistency upon standing in the package.

This action is somewhat similar to that which takes place when the material "livers" or "puddings," except it does not proceed quite so far when spoken of as "bodying action."

Bodying action in a lacquer product may be attributed to evaporation of volatile materials, or, in conjunction with this, the presence of an acid condition in the component or components.

**BODY ON THE WORK.** Meaning the thickness of a dried film of lacquer on the work. Since some use the term "body" to designate the consistency of the lacquer, it is better to use the term "fullness" to designate the thickness of the film.

**BOG OAK.** This term originally described the black oak produced in oak logs that had laid buried for years in bogs. Today it is imitated by the use of black stains on natural oak.

**BOILED OIL.** Linseed oil that is heated until it is partially oxidized and consequently dries faster than raw linseed oil is known as "kettle boiled" oil. Modern kettle boiled oil is not heated so long or at such a high temperature as formerly and often a small amount of drier is added during the heating process. So-called "bung hole" oil is also made by adding a small amount of strong liquid drier to the raw linseed oil without heating it at all.

**BOILING POINT.** The boiling point of a material is the temperature at which the vapor pressure of the material equals the air pressure, that is, the temperature at which the material begins to boil.

**BOILING RANGE.** The thermometer indicated range within which a liquid boils to dryness.

**BOLD.** One of the size gradings of the various gums or resins. Very large pieces of gum resin free from dust, dirt and small pieces of gum resin are called bold. Also sometimes called "sorts."

**BOND COAT.** A coat of finishing material used to improve the adherence of succeeding coats. See *First Coater*.

**BONDING ACTION.** The condition of adhering or bonding between applied coatings or surfaces.

**BONE BLACK.** Another name for drop black, indicating that the pigment is made from calcined animal bones. Very dark in color but not of strong tinting strength.

**BONE CHARCOAL.** The calcined residue of animal bone from which drop black is made.

**BONE DRY SHELLAC.** A bleached, light colored gum resin. Soluble in alcohol in which state it can be considered a finished product or may be added to nitrocellulose lacquers.

**BOTTOM DRYING.** Certain types of materials which when added to a product cause it to dry from the bottom up. Such a material which dries from the bottom up is much less likely to show checking or cracking defects than one which dries from the top down. This term is allied with the phenomena of paint and varnish as well as synthetic enamel drying. Lacquers dry from the top downward.

**BREAKING.** The break in an oil is the flocculent material or "foots" which separate out upon long standing or upon subjection to heat. Varnishes are said to break when a portion of the resin or drier separates from the liquid. This

term is also used to describe the defect which sometimes appears in a coat of paint soon after application when the liquid separates from the pigment, especially on vertical surfaces, and runs down in crooked channels or "spider legs."

**BREAKING UP.** When thinning lacquer pastes it is necessary to add thinner or base (nitrocellulose) to obtain a uniform mixture. This process of stirring the lacquer paste with only a small amount of lacquer thinner or nitrocellulose base until it is thoroughly mixed with the paste is known as "breaking up" of the paste. This process is repeated until the desired consistency is finally reached.

**BRIDGING.** A film condition usually present in final coat lacquer application. The result of too heavy an application of lacquer, too fast a thinner or volatile or temperature conditions which excite a rapid top drying action will cause this trouble.

**BRIGHTNESS.** An expression sometimes used to define the clarity or fullness of a coating film.

**BRILLIANCY.** The brightness or apparent strength of a color to the eye is its brilliancy. This attribute of color corresponds to the loudness of sound. Brilliancy is also used to describe a glittering surface. For example a very high lustre is sometimes spoken of as a brilliant lustre.

**BRITTLE.** A dried lacquer film is said to be brittle when it is easily broken or is not tough or tenacious, especially when bent rapidly or scratched, as with a knife blade or the finger nail. The opposite of tough.

**BRITTLENESS.** The determination of resistance to abrasion. Brittleness and shortness are synonymous. See *Shortness*.

**BRONZE POWDER.** Particles of metals or alloys hammered to a very fine degree (powder fineness).

**BRONZING LACQUER.** Pale and clear nitrocellulose solutions for application onto bright metal.

**BRONZING LIQUID.** A lacquer of thin consistency and containing only a small amount of binder into which bronze powders are mixed to make bronze lacquers.

**BRUSHING.** A finishing material is said to be a "brushing" piece of goods when it is capable of being applied with a brush.

**BRUSH MARKS.** Marks of the brush left in a dried film of a finishing material. Caused by working the material after it has begun to set, due to the fact that the material is not properly constructed to flow out level after it has been brushed. Can sometimes be prevented in lacquers by reducing them slightly before application.

**BUBBLING.** A term used to describe the appearance of bubbles on the surface while the material is being applied. Bubbles may also be found in the finished work after the film is dry which were unnoticed while the material was being applied. In such cases the bubbles may be caused by several things. On veneered work, improperly greased caul boards often contain small quantities



of paraffin or some greasy material which may become mixed with the glue in the pores of the veneer during the gluing process. The grease may confine tiny bubbles which are not released until the solvent cuts through the grease and releases the air. By the time this happens the lacquer is usually hardened and prevents the air from escaping freely, in which case it raises a bubble. In such cases of grease in the glue it has been found that a slight wash with a solvent rag before applying any finishing material cuts the grease and releases the air.

If the stain coat on wood is not thoroughly dry when succeeding coats of finishing material are applied, higher temperature at a later date may cause the moisture or other volatile materials to evaporate and cause bubbles or blisters. Creosote and other high boiling materials which may not be thoroughly evaporated from the stain before the finishing coats are applied may later evaporate and cause trouble. Bubbles and blisters from this cause are most frequently on oak because of the depth of the pores, also prevalent on Philippine mahogany.

Undried filler coats sometimes cause bubbling. Care should be taken to see that the filler is thoroughly worked and pounded into the pores of the wood when it is applied so as to expel all air from the pores. Bad cases of bubbling have been traced directly to poor filling of the pores, whereby small air pockets were left below the filler and when the latter was warmed, this air expanded and caused bubbling. In some cases where lacquer is applied too thin, there is not enough material on the work to allow the bubbles to flow out as they should. Too heavy an application of lacquer may also result in this trouble.

Bubbling is described as the presence of small air bubbles in a dried film, which, when rubbed, are broken into, leaving pumice stone or such abrasives behind to show up as small white specks as soon as the rubbing liquid has evaporated. Bubbling generally shows up near the edges or sharp corners of the work where the lacquer is applied most heavily. It may sometimes be caused by the lacquer solvents not being properly proportioned to give the right scheme of evaporation, or by the lacquer being too heavy or viscous for application. Bubbling from these causes is very infrequent with a properly made lacquer; the most common cause is due to improper application.

If the mixture of air and lacquer is not properly proportioned, if the spray gun is held too close to the work or too far from the work, if the strokes are not uniform, or if the gun is pulled away from the work near the end of the stroke, bubbling may result. Lacquer should be applied with a spray gun so designed and adjusted as to properly break up or atomize the material and yet give a wet coat on the work, when held 6 to 8 inches away from the work.

Whether the object being coated is wood or metal, start at one end of the surface and go all the way across to the other end. Be sure to open the gun before striking one end of the work; then go beyond the other end before swinging back in the opposite direction, or there will be danger of piling up the lacquer too much on the ends, which produces an excellent condition for bubbles to form. Do not shut off the gun at the end of each stroke but hold it

open all the while the work is being coated. Use an even swinging motion just fast enough to give a good, even wet coat without sagging.

Hold the gun at the same distance from the work and at right angles to the work at all times. Be especially careful not to pull it away from the work at an angle at the end of the stroke. This can be accomplished by moving the entire arm in going from one end of the work to the other. Some spray men make the mistake of using their wrist too much and their arm not enough. This causes the gun to be pulled away at an angle near the end of the stroke and it is probably the greatest single cause of bubbling in lacquer.

Regardless of what the exact cause of bubbling may be, the fundamental reason for its happening is that the top of the lacquer film becomes partially set and dry enough so that most of the solvents have evaporated. The result is that solvent gases form under the film and produce bubbles. Bubbles may be eliminated from lacquer in many cases, when they are present, by spraying on a good coat of lacquer reducer, or lacquer itself which has been reduced somewhat.

**BUBBLING TEST.** In comparing the viscosity or consistency of a lacquer with another lacquer or solution of known consistency, the material is placed in a small glass tube and placed in a vertical position beside a similar tube of the known material. By inverting the tubes quickly and noting the comparative rate of rise of the bubbles the comparative consistency or viscosity of the new material is established. This test is known as the bubble test and offers a rapid, comparative method of observing the consistency of a material. This test, however, is only applicable to clear lacquers. See *Gardner-Holdt Tubes*.

**BUFFER COAT.** A coat of finishing material applied over the old finish to protect it from the solvent action of the new finishing material. A buffer coat which may consist of a primer, shellac, or other suitable material is often applied over the old finish, especially if it is paint or varnish, before new coats of nitrocellulose lacquers are applied.

**BUHR MILL.** A stone mill used in paste grinding. Usually one stone is stationary and the other revolves while pressed closely to the first. The paste is passed between the stones and in this manner the pigments are ground finely and thoroughly, wet by the oils or other grinding liquids.

**BUILDING COATER.** An application showing great building ability; usually referred to in lacquers of high solid content. Also see *Liquid Fillers*.

**BUILDING COATS.** These coats used for building up the surfaces before rubbing. Used especially in connection with finishing pianos and fine furniture. Building coats are also referred to as foundation coats and with reference to sanding sealers in furniture finishing.

**BULKING VALUE.** The bulking value of a pigment is its ability to add volume to a liquid when ground in it. The bulking value depends upon the specific gravity of the pigment although the oil absorption, fineness of grind and similar conditions also have some effect upon the results in actual practice. The bulking value is usually expressed in gallons added by grinding 100 pounds of the pigment. Bulking value is also allied with resin and nitro-

cellulose, as solutions in which they are incorporated are in like manner increased in volume.

**BURNING.** When a finishing material is rubbed too dry without enough oil and water to lubricate the pad sometimes the heat generated by the friction softens the material and causes it to stick to the pad. This is sometimes referred to as "burning" the finish. Other attributes to the condition referred to as "burning" may be lack of adhesion, especially so on motor car surfaces, whence it has been attributed to surfacing materials leaving the metal. This is especially true of nitrocellulose type primer and surfacer combinations.

**BURNING IN.** The process of repairing scratches and other damaged places in a finish by melting "stick shellac" into the defect by means of a heated knife blade.

**BURNT UMBER.** Burnt umber, a pigment, is made by heating raw umber and has a reddish tone, more so than raw umber.

**BURNT SIENNA.** Burnt sienna, a pigment, has a more reddish cast than raw sienna and is made by heating raw sienna.

**BUSH KAURI.** A gum resin of modern origin, obtained from the living trees (kauri) in New Zealand. It is of softer nature than the fossilized kauri gum.

**BUTANOL.** See *Butyl Alcohol*.

**BUTYL ACETATE.** ( $\text{CH}_3\text{COO.C}_4\text{H}_9$ ) A lacquer solvent produced from butyl alcohol by a reaction with acetic acid. It is water white in color and has a characteristic ethereal odor. Butyl acetate is a "middle" boiling solvent and used to great extent in lacquer manufacture.

**BUTYL ACETYL RICINOLEATE.** ( $\text{C}_{18}\text{H}_{33}\text{O}_3\text{C}_4\text{H}_9$ ) A yellow oily liquid used as a plasticiser/emulsifier in lacquers.

**BUTYL ALCOHOL.** ( $\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH}$ ) An alcohol of a higher boiling range than grain alcohol or wood alcohol. It is obtained from corn by fermentation. It is valued for its bluish retardent nature and is used extensively in lacquer manufacture. Butyl alcohol in the presence of a minimum amount of an ester excites solvation on nitrocellulose.

**BUTYL LACTATE.** ( $\text{CH}_3\text{CHOHCOOC}_4\text{H}_9$ ) A water white high boiling and oil like liquid — little odor and non-volatile — used in lacquers.

**BUTYL PROPIONATE.** ( $\text{CH}_3\text{CH}_2\text{COO.C}_4\text{H}_9$ ) A high boiling nitrocellulose lacquer solvent, made by the reaction of butyl alcohol with propionic acid, which is used to a considerable extent in small quantities in lacquers to prevent them from blushing.

**BUTYRONE.** See *Dipropyl Ketone*.

**CADMIUM LITHOPONE.** A series of reds and yellows that are permanent to light, resistant to alkalis and intermixable with other pigments. They contain about 30 per cent CdS (Cadmium Sulphide).

**CADMIUM RED.** A non-fading red pigment, alkali and heat resistant. Manufactured from cadmium and selenium metals.

**CAGE MILL.** A mill for dry grinding, consisting of two concentric squirrel cage-like parts rotating in opposite directions, the material being fed into the inner cage.

**CAKING.** A term often connected with varnishes rather than lacquers. During the rubbing process the varnish sticks to the rubbing pad and forms a cake which will mar the rubbed surface if it is not removed. This formation of a cake of varnish on the rubbing pad is what is known as "caking." The terms "picking up" and "pulling out" describe the condition when small spots of varnish are apparently pulled out during the rubbing operation.

Some of the more common causes of caking are: Improperly dried varnish, insufficient water, inferior pumice stone, too much friction on the rubbing block, improper type of rubbing felt, dirty varnish and similar causes.

By adding soap to the rubbing water until a nice sud is formed, many finishers are able to cure the tendency of caking. It is said too that varnish can be rubbed greener if soapy water is used.

A little rottenstone mixed in the pumice stone will sometimes eliminate caking. The finished work will have a little higher lustre than if straight pumice is used, however.

Coarse felt that contains no hard ribs will not cake as rapidly as a finely pressed felt, because the pores or air pockets in the coarser felt are not so easily closed up after it is wet and in use.

Where rubbing machines are used, care should be taken to move them over the surface in such a way as to cause as little heat from friction as possible.

The pulling out or picking up of varnish during the rubbing operation may be caused by the use of dirty varnish or by allowing specks of dirt to settle on the wet varnish before it has dried sufficiently to become dust free.

Many rubbing varnishes of excellent quality show a tendency to form a thin skin on the surface if allowed to remain exposed to the air for some time in partially filled packages, or in drums where the bung has been left open. This partially hardened mass may escape unnoticed until broken up into very small particles by the spray gun. As a rule these gummy particles do not dry as well as the liquid varnish. As a result they may stick to the pad during the rubbing operation and produce pull outs or other imperfections in the finish.

If sufficient lubricant (water or rubbing oil) is not used with the pumice stone the excessive friction is likely to generate enough heat to soften the varnish and cause caking or picking up. Trouble is also caused by using a poor grade of pumice stone that powders up like clay and cakes on the pad. If the pumice contains any grit or harsh materials it may cause trouble by producing severe scratches in the surface. See *Picking Up*.

**CALCINED.** A material is calcined when it is heated to a high temperature in the absence of air. This process is used in the preparation of a number of pigments.

**CALCIUM CARBONATE.** ( $\text{CaCO}_3$ ) The chemical term of calcite or whiting. Chemically it is the combination of calcium with carbonic acid and is obtained from natural deposits of chalk, calcite or dolomite.

**CALCIUM SULPHATE.** ( $\text{CaSO}_4$ ) A white inert pigment which is practically free from color and opacity when ground in oil or grinding vehicle of the lacquer paste stone grind type. Chemically, it is the hydrated sulphate of calcium. See *Gypsum*.

**CAMPHOR.** A white, translucent solid of a peculiar characteristic odor, which is derived from a species of laurel tree grown chiefly in Formosa. In the earlier days of lacquer it was used as softener or plasticiser to give a flexible film. It is seldom used in present day lacquer manufacture because of its high volatility.

**CANDELILLA WAX.** A wax obtained from a small shrub grown in Mexico and Texas. It is a little softer than Carnauba wax, having a melting point of about  $156^\circ \text{F}$ .

**CAPRYL ALCOHOL.** ( $\text{C}_8\text{H}_{18}\text{O}$ ) A water white liquid—sweet odor—used in manufacture of high boiling esters.

**CARBITOL.** (Diethylene glycol ethyl ether) A colorless oil-like liquid. Pleasant odor. A solvent for lacquers and resins.

**CARBON BLACK.** A black pigment produced by burning natural gas in an insufficient supply of air. It has a different color tone than lampblack, more like that of drop black. A typical analysis of carbon black is:

|                |       |
|----------------|-------|
| Carbon .....   | 98.8% |
| Moisture ..... | 1.2%  |

**CARBON TETRACHLORIDE.** ( $\text{CCl}_4$ ) A noninflammable liquid that has good solvent properties for many gums or resins. Used to a very small extent in lacquer manufacture.

**CARBONATE WHITE LEAD.** See *White Lead*.

**CARMINE.** A brilliant red lake pigment prepared by bleaching the color from the dried body of the cochineal and precipitating it on an alumina hydrate base. Very bright in color but has little hiding power and must be used over a solid covering ground color of a similar shade.

**CARNAUBA WAX.** The hardest wax in use, having a melting point of about  $185^\circ \text{F}$ . It is obtained from the surface of leaves of a species of palm grown in Brazil and has a yellowish color. Carnauba Wax is sometimes used in the manufacture of flat lacquers, though its principal application is in the manufacture of wax polishes.

**CASE HARDENING.** It has been found that when the relative humidity of the atmosphere is too low many products of the paint and varnish type are likely to case harden. By this is meant, they dry hard on top and remain more or less soft and mushy underneath instead of drying thoroughly throughout the film.

When the finish dries in this manner, checking, cracking and alligating are likely to take place when the underneath portion of the film finally becomes hard. Case hardening can be prevented by increasing the amount of moisture or the relative humidity of the atmosphere. From 35 to 45 per cent relative humidity has been found about right for most paint and varnish materials at ordinary drying temperatures below  $120^\circ \text{F}$ .

- CASTOR OIL. A vegetable, non-drying oil derived from the castor bean. Used to some extent as a softener or plasticiser in lacquer products. Its greater outlet in this connection, however, is as a grinding vehicle for lacquer paste colors. The heavy bodied castor oil of the blown variety is used to greater extent than the C.P. grade.
- CATALYST. Derived from the word catalysis—a substance which by its mere presence alters (initiates or accelerates) the velocity of a reaction between two or more substances.
- CAUL BOARDS. The boards between which veneered work is laid at the time the veneer is put in a press to hold the sheets together until the glue dries hard. Crude vaseline, paraffin, fish oil or other greasy materials are often used on caul boards to prevent them from sticking to the veneer. The heat and pressure of the gluing process transfers some of this grease to the veneer and drives it deep into the texture of the wood. Scraping and sanding does not remove the grease nor does washing the work with naphtha, although the last procedure helps somewhat. By applying a thin coat of shellac, pinholing from this cause can be eliminated.
- It is better practice, however, to remove the cause than to cover it up. Aluminum cauls do not stick so easily and many manufacturers are now using them. A mixture of five pounds of beeswax dissolved in a quart of raw linseed oil has given satisfaction to some manufacturers as a compound for preventing zinc or iron cauls from sticking to the veneer. This compound contains no non-drying oils and will be less likely to cause pinholing.
- CAUSTIC SODA. Sodium Hydroxide (NaOH).
- CEDAR OIL. An essential oil found in cedar wood which imparts the characteristic odor of cedar. Sometimes used in furniture polishes.
- CELLOSOLVE. (Ethylene glycol ethyl ether) A mild ethereal-like odored liquid used in lacquers.
- CELLULOID. A gel. Nitrocellulose kneaded with alcohol and camphor.
- CELLULOSE. The principal constituent of raw cotton and many other fibres obtained from the vegetable kingdom. Of interest to the lacquer industry because of the fact that nitrocellulose, which is used so extensively in lacquer, is prepared from cellulose by treatment with chemicals.
- CELLULOSE ACETATE. A compound of cellulose materials, such as cotton or wood pulp, in a mixture of acetic acid and acetic anhydride. In conjunction with plasticisers, it may be coated from volatile solvents as a tough, clear colorless sheet. In conjunction with dye or pigment, it may be formed into molding compounds or may be spun from volatile solvents into a synthetic fibre or rayon.
- CELLULOSE NITRATE. See *Nitrocellulose*.
- CEMENT PAINT. A type of paint designed for the preservation of cement, concrete or plastic surfaces, characterized by permanent adhesion to the surface and retention of original color.
- CENTIGRADE. The temperature grade on which freezing point of water is 0° and the boiling point is 100°.

- CENTRIFUGAL CLARIFIER.** A machine somewhat similar to a cream separator, used for clarifying clear and colored lacquers, by throwing out the lacquer solid particles by means of centrifugal force. Clarifiers of this type are operated at high speed. The bulky and apparent undissolved particles are thrown aside in a container.
- CERESIN.** A wax of non-crystalline nature with a melting point about 190° F. Obtained from ozokerite.
- CHALK.** A natural, soft, white mineral usually of sea shell origin which is one source of whiting, when ground and purified. Essentially calcium carbonate.
- CHALKING.** A finishing material is said to chalk when it can be rubbed off in the form of a white powder by friction of the finger or by similar methods. A pigmented lacquer is said to chalk when a white powder forms on its surface, especially during exposure to the weather. Caused by disintegration of the binder.
- CHAMOIS SKINS.** Soft, pliable animal skins, used for wiping off the last traces of water after washing a finished surface. Chamois skins, of which there are three grades — American, English and French — should be cared for as carefully as their cost demands. In using the chamois it should be carefully soaked in clean water until it is entirely soft and pliable. The excess water should then be wrung out and used with a light, uniform pressure in wiping excess moisture from the body. No attempt should be made to wipe the surface absolutely dry, since to do so requires too much pressure with danger of damaging the film as well as the chamois skin. Any slight remaining mist of moisture will quickly evaporate.
- After each use the chamois should be washed in a mild soap solution, by rubbing freely between the hands until all dirt and contamination has been washed out. Then rinse thoroughly in clean water, wring dry, stretch to original size and shape by pulling in all directions with hands and then hang up to dry. When dry, put away where it will not collect dirt and moisture.
- CHARCOAL.** Charcoal is obtained by partially burning wood in an insufficient supply of oxygen and consists essentially of carbon. Where some special properties are desired in paints, small quantities are used. Also sometimes used as an abrasive in rubbing finishes.
- CHASER.** A mill which consists of a rather shallow circular pan in which one or more heavy rollers, usually of stone, run about a central axis. Used principally for grinding rather stiff paste materials such as putty.
- CHEAP FINISHES.** Finishing materials that are not carefully compounded on a quality basis and usually used where appearance or permanence are of a secondary nature.
- CHECK.** To stop the rise in temperature in cooking a varnish or to hold it within a range of 10° F.
- CHECKING.** Checking is very similar to alligating, except that the finish is broken into smaller segments when checked than when alligatored. The causes are many and varied. Any of the causes mentioned under alligating might result in checks. Improperly dried veneer on furniture may contract sufficiently after being coated to disrupt the finish and cause severe cracking.

Likewise, unprotected edges may absorb enough moisture during the rubbing process to cause checking. Too heavy lacquer applications, or a brittle coat, such as a heavy coat of shellac directly under the lacquer, may cause checking or cracking. Checking might be described as that form or state of disintegration of a film in which the cracks are deeper than in crazing, but not as deep as in cracking or alligating.

**CHEMICALLY PURE.** Of a definite chemical composition; free of adulteration, extenders or diluents. See *C.P.*

**CHILL.** To drop the temperature of a cook (in the varnish kettle) in excess of 10° F.

**CHINA CLAY.** An inert pigment consisting essentially of a hydrated aluminum silicate. China clay gives greater bulk than most other inert pigments and when of a good quality is very smooth in texture. It has a tendency to impart the property of easy brushing to paint, but also has a tendency to settle in the package. It is very inert chemically, being decomposed only by prolonged heating with strong acids or by heating to the melting point with alkali. Ordinary atmospheric conditions do not affect it.

**CHINAWOOD OIL.** An oil which is obtained by pressing the nut of the tung tree which grows in China and in neighboring lands. Formerly this oil was not considered of much value to the paint and varnish industry, but today large quantities are used in making some of the finest varnishes on the market. Chinawood oil is never used in the raw state except for a few special purposes, since it dries to a flat, non-lustrous film. After being treated with heat it dries with a glossy finish. The tung trees from which this oil is secured have been successfully introduced into Florida and other Southern States. See *Tung Oil*.

**CHINESE BLUE.** Another name for *Prussian Blue*.

**CHIPPING.** A term used to express the condition of the finish flaking off or chipping away from the underneath surface. Sometimes caused by the finish being bruised, or may be due to the finishing material not being sufficiently elastic, or insufficient adhesion to the underneath surface.

**CHIPS.** One of the size gradings of various gums, being a little larger than seeds but not as large as bold or nubs.

**CHROME GREEN.** A mixture of chrome yellow and Prussian blue, which for best results are precipitated together during the process of manufacture. Has good hiding power and is fairly permanent to light. The color is readily changed by alkali. For commercial purposes, chrome green is usually "let down" by being precipitated on a base of barytes, because of its extremely good hiding power. Different shades of chrome green are secured by varying the strength and proportion of the chrome yellow and Prussian blue.

**CHROME ORANGE.** Basic lead chromate, which is usually made by treating lead chromate with lime.

**CHROME YELLOW.** A yellow pigment made of the mixture of solutions of lead acetate and potassium bichromate. According to the strength of the solutions, the temperature at the time of precipitation and other such fac-



tors, the color varies from a lemon yellow to a dark orange; chrome yellow has a good hiding power and a bright color, but is inclined to fade upon exposure to light. The color is also affected by contact with materials containing sulphur, such as other pigments.

**CHROMOMETER.** An apparatus used to indicate the color of oils and light liquids.

**CISSING.** Another term for the defect known as "crawling."

**CITRONELLA OIL.** An essential oil with a peculiar odor. Obtained from a species of grass of southern Asia.

**CLEAR FINISH.** A material of amber cast, transparent in nature.

**CLEAR FINISHING.** Usually referred to if and when a clear application is applied over-all on a coated object. The art of applying clear finishing materials.

**CLEAR TONE.** A finish is said to have a clear tone, when it shows clear without any sign of muddiness.

**CLOSE DRYING.** A material is said to be close drying when it does not show much fullness or body on the work. Oftentimes, the true fullness is not brought out until after rubbing. This is especially true with lacquer finishes.

**CLOUDINESS.** When a material is not clear and bright it is said to be "cloudy" or to show "cloudiness" on the work. The term cloudiness is sometimes used in conjunction with blushing. Cloudiness can be attributed to the hygroscopic nature of some solvents used. See *Blooming*.

**CLOUDING.** Very similar to "blooming." A loss of lustre with the accompanying appearance of a cloud film. May be caused by coal gas, ammonia fumes, or by similar causes. This term is also applied to a cloudy or murky appearance in the package.

**CLOUD POINT.** The cloud point of a liquid is an expression of the adulteration or admixture with another substance. It is the determination of what volume may be added; e.g., the cloud point has been reached when 10 per cent is added. See *Cloudiness*.

**COAGULATE.** To change from a liquid to a thickened curdled state.

**COAL OIL.** See *Kerosene*.

**COAT.** When used as a verb "coat" means to cover or to apply. As a noun, the word is more difficult to define. Most everyone that is at all familiar with paint, varnish or lacquer knows fairly well what a coat of finishing material is but if asked to define a coat will usually give up in despair. Perhaps the best definition yet given of what a coat consists of is the following:

"A coat of finishing material is said to be applied when one puts on, in a uniform film, all of the particular finishing materials that can be applied to an upright surface without producing runs and sags." The more you think about this question the more accurate the above definition seems. Whenever the quantity of material, other than that mentioned above, is applied, it is customary to prefix an adjective to the word coat, as for example, a "wash coat" or a "thin coat" or a "heavy coat," etc.

The word "coat" is not exactly synonymous with the word "application." For example, one may put on two applications of a material, one immediately following the other, and still have one coat on the work. An application is usually considered to be material deposited by going over the entire surface one time, especially when speaking of the spraying method.

**COATING.** The application of drying materials for decorative, preservative, etc., purposes is usually referred to as such.

**COBALT BLUE.** A blue pigment made by heating a mixture of an alum compound with cobalt phosphate. The final chemical composition of this pigment shows it to consist principally of alumina and cobalt oxide. Cobalt blue has a cleaner tone than ultramarine blue. It is one of the most permanent blues to be had since it is not affected by acids, alkalies, light or heat.

**COEFFICIENT OF EXPANSION.** When wood, metal, films of paint, varnish or lacquer and most other substances are heated they expand. Similarly they contract when cooled. All materials do not expand or contract to the same degree with a given change of temperature and this accounts for many of the checking and cracking troubles which develop in finishes.

The ratio of the increase of length of a material as compared to the original length, for each rise in temperature of one degree is the coefficient of the material.

**COHESION.** Latin; con and haereo; stick together. "That form of attraction by which the particles of a body are united throughout the mass." — Webster. Lacquer coatings stick to the work principally through cohesion, which results in the film being stretched tightly over a surface in much the same way that a rubber band stretched tightly over a surface has a tendency to stick to it. Paint and varnish materials stick to the work mostly by adhesion, in much the same way as molasses or glue. Of course, it is generally assumed paint and varnish materials properly constructed have some cohesive properties to hold the individual particles together and all good lacquers must have some adhesion to make them stick to the work if the film is broken, but the main forces causing sticking are as described above.

**COLD CHECKING.** See *Temperature Checking*.

**COLD COLOR.** A color is said to be cold when it has a bluish or greenish tone, or is not suggestive of warmth.

**COLLOID.** Specifically, a substance of gelatinous nature, "solutions" of which do not exhibit the characteristics of true solutions, such as lower freezing point and higher boiling point. Generally the term is applied to both organic and inorganic materials exhibiting similar behavior, the "solutions" of which may actually be fine suspensions.

**COLLOIDAL SUSPENSION.** An insoluble substance which is divided into such fine particles, by grinding or otherwise, that it remains in permanent suspension in a liquid is said to be a colloidal suspension or solution.

**COLOPHONY.** See *Rosin*.

**COLOR.** A term used to express the degree of darkness in clear finishes, such as "pale color," "amber color," etc. Color is determined by the effect of cer-

tain wave lengths of light upon the retina of the eye. An object is said to have a blue color if it is so constituted that all light waves are absorbed by it except those which produce the sensation of blue in the retina, these being reflected.

An object is black when all wave lengths of light are absorbed and none are reflected. It is white when all wave lengths of light are reflected and none are absorbed; it is green when only those light waves producing the sensation of green are reflected; and so on. Color is divided into three main parts, namely: hue, tint and shade. The hue of the color is the quality of it; that is, red, green, blue, etc. The tint is the quality of a particular color present, as: a pale tint of blue. Shade expresses the purpose or degree of color, as: a darker shade of red. The word "color" is also used to denote the pigments used to produce various colors in paints, enamels and lacquers. It is also used to express the act of applying color to an object by means of paint, lacquer, stain or similar materials. See *Hue*.

**COLOR ANALYZER.** An instrument used to analyze colors in combination of a given substance. The use of light beams which are dispersed and are passed onto a photo-electric cell and are recorded on a rotating drum. See *Colorimeter*, *Spectrophotometer*.

**COLOR CHIP.** A small piece of paper, celluloid or similar material, coated with finishing materials, and used as a color sample.

**COLOR FLOAT.** When one or more colors, other than the original color of the finishing material, appear on the surface after the material has been applied and during the drying operation, it is said to have a color float. This frequently appears in dipping colors although it may also appear on sprayed or brushed work. It is caused by the difference in specific gravity of the various pigments used in the manufacture of the particular material, the pigments not being thoroughly incorporated, by the use of tinting colors ground in a different type of liquid than that composing the main body of the material and by similar causes. The absorptive wetting of a part of the pigment — balanced by a capillary wetting of other component pigments of opposite polarity — is considered by some to correct floating of pigment colors. If this is so, the floating is principally a matter of charge on the particles which may be defined as electrostatic repulsion from the vehicle.

**COLORIMETER.** An instrument for measuring the type and quality of color, either by comparison with standards or by means of light waves or by other means. Also see *Color Analyzer*.

**COLOR IN JAPAN.** When colors are ground in japan drier, the product is sometimes referred to as color in japan. Also spoken of as "japan color." Such colors should not be used with lacquers.

**COLOR IN OIL.** A term used when the dry color is ground in oil. Also spoken of as "oil color." Such colors should not be used with lacquers.

**COLOR IN VARNISH.** A dry color ground into varnish. Also called "varnish color" or "color varnish." Such colors should not be used with lacquer.

**COLOR IN WATER.** A dry color ground in or mixed with water. Also known

as "water color." Sometimes used for graining purposes. Such colors should not be used with lacquer.

**COLOR RETENTION.** When an enamel as exposed to the elements shows no signs of changing its color it is said to have excellent color retention.

**COLOR STABILITY.** A pigmented product is considered stable when it shows no color change in the wet state.

**COLOR STANDARDS.** A set of color standards for comparing and classifying the color of oils, varnishes, lacquers, paints, enamels and similar materials. These standards may consist of similar materials of approved and acceptable colors or may be made of other materials such as colored glass, solutions of potassium bichromate, burnt sugar, etc., or other substances of constant color value.

**COMMERCIALLY PURE.** This term is intended to define the purity of a substance on the basis of accepted commercial standards. Since there is more or less confusion as to how pure a commercial product may be, it is advisable to avoid the use of this term if possible.

**COMPARTMENT CAN.** A type of can having two separate compartments in one of which the liquid is placed and in the other the pigment, so they may be kept separate until ready to use. Used mostly for bronzing mediums.

**COMPATIBILITY.** Ability to become blended with others, e.g., the compatibility of a solvent.

**COMPLEMENTARY COLORS.** Two colors are complementary to each other if they are such as when mixed in the right proportions they will produce white or gray. Red and bluish green are complementary colors as are orange and greenish blue, yellow and violet and green and purplish red.

**COMPOSITION LEAF.** A thin leaf of bronze, sometimes called "Dutch Metal," chiefly manufactured in Germany (none in U. S.) used for decorating where temporary effect of gold color is wanted and the cost of genuine gold is not justified. Usually  $5\frac{1}{2}$  inches square and packed in books of 25 leaves each, 20 books to a pack. Also comes in rolls 67 feet long by any width up to 5 inches.

**CONDENSATE.** Any product which is obtained by cooling the vapors of a material that is being distilled.

**CONDENSATION.** The act of cooling or condensing vapors of any material that have been driven off by the application of heat.

**CONCENTRATION.** The amount of substance (weight or per cent) contained in a unit volume of solution.

**CONGO GUM.** A fossilized gum resin obtained from the Congo region of Africa. Used mostly in manufacturing varnishes. It is not as hard as Kauri, Amber or Zanzibar.

**CONSISTENCY.** The limpidity or degree of firmness in a finishing material. See *Body*.

That property of a material by which it resists permanent change of shape and is defined by the complete flowforce relation. If in non-turbulent flow, the ratio of flow to force is constant, the material is constant, the material is said to be fluid; otherwise it is plastic. (Journal of Rheology.)

**CONSTANT HUMIDITY.** Without change. A constant percentage of humidity. Usually referred to as a condition of a room.

**CONTRACTION.** To shrink. The opposite of expansion.

**COPAL.** The so-called "hard-gums" or fossilized gum resins which were exuded from living plants centuries ago and have fossilized while in the ground. Some of the copals are: Zanzibar, Amber, Kauri, West India Gum, Manila, Pontianak and Congo. See *Gum*.

**COPPERAS.** The common name for ferrous sulphate, one of the materials used in the manufacture of Prussian Blue pigment. See *Prussian Blue*.

**CORE.** In speaking of veneered wood, the core is the central piece of plywood used in the construction of the veneer. In five-ply construction, the grain of the core is parallel to that of the veneer, and at right angles to that of the crossbanding, which lies between the core and the veneer on either side.

**CORN OIL.** An oil obtained from the kernel of corn. Not used in the paint, varnish and lacquer industry because it does not dry as rapidly nor as completely as many other vegetable oils.

**CORROSION.** Used synonymously in paint, varnish and lacquer industries with the term rusting. It is now an accepted fact that corrosion is dependent largely upon "auto-electrolysis"; that is, electrolysis due to electric currents set up between different parts of the material itself. The presence of impurities or severe stresses in the metal produce differences of electrical potential in various parts of the metal or in other words produce electrodes or terminals similar to those in a battery. The moisture in the air is sufficient to serve as an electrolyte and to close the circuit between these terminals. When these small currents start flowing, the oxygen in the air attacks the iron, forming the basic oxide commonly called rust.

Iron cannot rust unless both moisture and oxygen are present, for without moisture the circuit cannot be closed and the iron cannot go into solution, and without oxygen the solution of iron cannot be oxidized into the form of rust. After rusting is once started, however, the chemical reaction is such as to regenerate over and over again a fresh supply of water and oxygen. For this reason it is very necessary to have metal thoroughly clean and free from rust before painting it, otherwise the rust will continue to grow under the paint film. Rust is the tendency of a metal to return to its natural state as an ore.

Priming coats should be made of a dense-drying vehicle so as to exclude as much moisture and oxygen as possible and neutral or slightly alkaline pigments should be used, for the presence of even small quantities of acid greatly increases the rate of corrosion. See *Anti-Corrosive — Inhibitor*.

**CORROSIVE.** That which produces or tends to produce corrosion.

**COSMIC BLACK.** Another name for drop black or bone black.

**COTTON LINTERS.** The short fibres of cotton which adhere to the cotton seed when cotton is ginned. These short fibres are cut from the seed with special machinery and used for the manufacture of nitrocellulose, which is used so extensively in lacquers,

- COUMARONE.** The oily material obtained as a product of the distillation of coal tar. When treated with sulphuric acid an artificial, or synthetic resin known as coumarone resin or para-coumarone resin is formed. This resin is used in the manufacture of acid and alkali resisting varnishes and lacquers and for similar purposes.
- COVERING POWER.** This term has been used very loosely and it is no longer possible to tell definitely whether it refers to hiding power, spreading power or the property of being brushed out to form a coat. It is advisable to avoid the use of the term if possible.
- C.P.** The abbreviation for "*Chemically Pure.*" Materials so described are generally considered to be of sufficient purity for use in chemical analysis, and the presence of any impurities is noted quantitatively upon the label.
- CRACKER JACK RUB.** When a surface is given only a slight rub—just enough to knock off the dirt nibs—it is sometimes spoken of as a "cracker jack rub."
- CRACK FILLER.** A quick drying paste made of pigment (inert and filler type) and binder for use in filling cracks in floors or other wooden surfaces before applying finishing materials.
- CRACKING.** Similar to "alligating." An intensification of the defect known as "crazing." Due principally to exposure to cold or to the application of a less elastic over a more elastic coat.
- CRACKLE.** The formation of pronounced fissures in the top coat of a finishing material, showing the underneath coat through the cracks. Very similar to alligating. Caused by the top coat drying hard before the underneath coating is thoroughly dry. Crackle lacquers are made purposely to produce this effect, which is very pleasing when properly carried out.
- CRACKLE FINISH.** Typically a wood finish in which alligating is purposely produced, the undercoat which shows in the cracks being of a different color than the top coat.
- CRAWLING.** A term to describe the refusal of a finishing material to remain spread in a continuous uniform coating after it has been applied. The finishing material appears to creep or crawl away from certain spots and leaves them uncoated.
- May be due to excessive viscosity, too low temperature, to moisture, grease, or other foreign material on the surface.
- Crawling may be caused also by an extremely high lustre or gloss on the underneath coat which does not allow the top coat to get a foot-hold. Excessive surface tension in the finishing material may also cause this trouble. "Cissing" is another term for the same effect.
- CRAZING.** The appearance of minute, interlacing cracks on the surface of a finish. Sometimes caused by sudden exposure to extreme changes in temperature, or to the use of a very heavy coat of shellac or such brittle material, followed by a hard drying finish. See *Cracking* and *Alligating*.
- CRIMPING.** Same as *Crinkling*.

**CRINKLING.** A term used to designate shriveling or crinkling of the fatty or thick edge of work coated by dipping or flow-coating. It is most frequently seen in baking japans, although it is sometimes found in air drying materials, such as varnishes applied with a flowing machine. Caused in air drying materials by the substitution of a few heavy coats for more thin coats; by the sudden lowering of the temperature before coating is thoroughly dry or by the presence of strong driers which cause the material to top dry, leaving the under portion soft and mushy. In baking materials, in addition to some of the above causes, crinkling may be caused by the temperature being raised to a high point too quickly so that the outer film of the fatty edge is dried first and when the underneath portion dries and shrinks it causes the top skin to shrivel or crinkle. See *Puckering* and *Wrinkling*.

**CRIPPLES.** Finished jobs which do not pass inspection and must be refinished or touched up.

**CROCKING.** In speaking of paints, lacquers, etc., the term is used to denote the quality of the color rubbing off on the clothing especially when wet.

**CROSS BANDING.** The layers of plywood directly beneath the face veneer, with the grain of the wood running at right angles to that of the veneer itself and to that of the core in five-ply construction is known as cross banding.

**CROTONIC ACID.** White crystalline substance used in the manufacture of synthetic resins and esters. Prevents sedimentation and gelatinization of varnish driers.

**CROW FOOTING.** A species of crystallization. See *Crystallizing*.

**CRUMBLING.** When the material does not contain enough binder to hold it, it is said to be crumbly. Used mostly in speaking of fillers and other heavily loaded pigment goods.

**CRYPTOMETER.** An instrument for measuring the opacity of paints, by measuring the thickness of film which will obscure a background consisting of two contrasting colors.

**CRYPTONE.** The name applied to a series of pigments composed in whole or in part of zinc sulphide, having high hiding power and frequently described as high strength lithopones.

**CRYSTALLIZING.** When varnish or other materials dry with a rough or crystalline surface instead of a clear, smooth surface they are said to crystallize. Caused by improper ventilation or circulation of fresh air; by gas fumes which reduce the oxygen content of the air; or by a cold draught blowing on the film before it is hard and dry. Products which contain considerable chinawood oil are most subject to this defect, which is called "filming." This characteristic of chinawood oil is made use of in the manufacture of crystallizing finishes with which a wide variety of effects can be produced. These products, however, are of varnish structure. Crystallizing lacquers are also produced, which have no bearing on the above statement with respect to chinawood oil. See *Crow Footing*.

**CURED RESIN.** A resin which has been subjected to prolonged heating in order to complete the chemical process of condensation and/or polymerization.

- CURLED HAIR.** A form of horse hair that is sometimes used to rub one coat of varnish or enamel to remove the lustre before another coat is applied.
- CUT.** Physical action by means of which a material is divided or severed. The action of cutting is partly plastic flow but also a breaking apart by the wedging or prying action of the knife or tool. In general the less the factor of plastic flow has in the process, the less will be the energy used up in the operation of cutting. The efficiency is often gained by reducing the consistency of the material. (Journal of Rheology.)
- CUTTING OIL.** An emulsion of soap and oil or alkali and oil which is used as a lubricant in cutting and boring metal. Because of its greasy and chemical nature, it should be thoroughly removed before starting to finish.
- CUTTING UP.** Cutting up takes place when one coating is applied over another with the result that the underneath coat is softened. Caused by the bottom coat not being sufficiently dry or by the top coat having extra strong solvent power.
- CYCLE.** The time indication involved in completing a given course; i.e., a cycle of weatherometer testing.
- DAMMAR.** A gum resin, usually of modern origin, used extensively in the preparation of pale varnishes and to a large extent in the manufacture of lacquers. In lacquers, dammar is added in the form of a solution. Such a solution is free of wax present in the resin. Dammar is usually classified according to the place from which it is shipped to market; as: Singapore dammar, Batavia dammar, etc.
- DEAD FLAT.** Having no gloss at all.
- DEADENING.** This term is used where a finish loses its lustre after being finished for some time, or where exposed to the outside elements with the result that the finish looks dead or dull. Also caused by unseasoned lumber, imperfectly dried undercoats and porous undercoats. See *Dying-Away*.
- DEBLOOMED OIL.** Many mineral oils show a decided blue or purple cast when examined in a test tube or when spread in a thin film over a dark colored surface. Such oils are said to possess a bloom. When an oil has been so treated as to remove this color effect it is said to be debloomed. Debloomed rubbing oil gives a clearer, sharper rubbed surface than those which show a bloom.
- DECALCOMANIA.** The process of transferring pictures or other decorations from paper to other surfaces which are to be decorated. The customary method of using decalcomania transfers for decorating finished work is to brush a small quantity of quick drying cement on the back of the transfer and when this has become sticky or tacky the transfer is placed in the desired position on the work and rolled or pressed flat and free from bubbles. The paper is then softened and removed from the design by sponging it with water. The excess cement is then removed from the edges of the design by wiping lightly with a cloth moistened with solvent. The transfer is then allowed to dry, usually over night, and a clear coat of lacquer is applied to protect it from wear.



**DEEP.** A finish is said to be deep when it apparently has great depth or thickness. This term is often used incorrectly for dark colors, as a deep shade of brown when a dark shade of brown is meant.

**DEFLOCCULATION.** The process of preventing flocculation, usually increasing the viscosity of the liquid.

**DENATURED ALCOHOL.** A strong solvent for many paint and varnish raw materials. Usually made by denaturing grain (ethyl) alcohol with certain compounds—usually of a poisonous nature—that render the resultant mixture unsuitable for beverage purposes. Wood (methyl) alcohol, benzol, pyridine bases and similar materials are used as denaturants, according to certain formulae specified by the United States Government. Denatured alcohol is used extensively in the manufacture of spirit varnishes and lacquers.

The United States Internal Revenue Bureau, which controls the distribution and use of denatured alcohol, specifies two main types of denatured alcohol, completely denatured alcohol and specially denatured alcohol, which are manufactured according to definite formulae approved by this department.

Completely denatured alcohol is ethyl alcohol which has been rendered entirely unfit for beverage use by the addition of denaturants prescribed by the U. S. Internal Revenue Bureau. Such alcohol may be used by the manufacturer or general public without filing a bond or obtaining a permit. Completely denatured alcohol is tax free and may be bought or sold without keeping records and making reports to the Internal Revenue Bureau.

Completely denatured alcohol is commonly used in cutting shellac and as a thinner for same. The alcohol manufacturers have recently introduced a revised completely denatured type of alcohol under their various trade names which have an addition of solvent i.e., ethyl acetate, and renders greater solvent power.

For most manufacturing purposes completely denatured alcohol will be found satisfactory but there are some cases where specially denatured alcohol is better suited. Specially denatured alcohol is ethyl alcohol which has been rendered partially unfit for beverage use by the addition of denaturants approved by the U. S. Internal Revenue Bureau. Specially denatured alcohol is not subject to tax but may be used only under permit and bond as specially authorized by the Internal Revenue Bureau. The application for a permit must be made to the local collector of Internal Revenue on form 1479. The bond must be executed on form 1480, the size of the bond being determined by the quantity of alcohol to be used each month. These bonds amounts and more detailed information can be obtained from the local collector of Internal Revenue.

Calol ethatate, a petroleum fractionation, has recently been introduced as a denaturant for specially denatured (ethyl) alcohol.

**DENSITY.** The comparative weight of a given volume of a material to that of an equal volume of a standard material, which is usually chemically pure water.

Density is also used as a term to denote the strength of color in speaking of colored materials. When a material covers quite solidly in one coat it is said

that the color has great density. Likewise, density is sometimes used to express freedom from voids or to express solidity, as a non-porous film is sometimes called a dense film. Because of these confusing uses of the term it should be avoided if possible.

**DEPTH OF FINISH.** The apparent thickness of the film on the work when clear finishing materials are used. A material is said to show great depth of finish when it apparently deposits a heavy, very transparent film which allows the natural texture and color of the underneath surface to show clearly but apparently below a thick coating.

**DESTRUCTIVE DISTILLATION.** Distillation of a product at temperatures so high as to cause chemical changes in the original product or in the vapors driven off by the application of heat. In other words, the condensed products produced by the distillation are of different chemical composition than as they existed in the original material and cannot be put together again to form the original material.

Until the comparatively recent development of the process for the manufacture of synthetic methanol, all of our large requirements of methyl alcohol were produced by the destructive distillation of hard woods, hence the name wood alcohol. In the destructive distillation of the Southern pine woods, the primary products are tar and pitch.

**DIACETONE.** A colorless odorless solvent, having a slow evaporation rate. Used expressly in acetate lacquer

**DIAMYL PHTHALATE.**  $[\text{C}_6\text{H}_4(\text{COO.C}_6\text{H}_{11})_2]$  A solvent for nitrocellulose, which because of its low vapor pressure and high boiling point is sometimes used as a plasticiser in lacquers. Made by the reaction of amyl alcohol with phthalic acid.

**DIATOMACEOUS EARTH.** Mass accumulations of the siliceous skeletons of the diatoms, a group of one-celled aquatic plants formed during the tertiary period millions of years ago, and varying in shape and character of their physical structure according to their original formation in salt or fresh water. See *Silica*.

**DI-BUTYL PHTHALATE.**  $[\text{C}_6\text{H}_4(\text{COOC}_4\text{H}_9)_2]$  An oily, colorless liquid made by heating butyl alcohol with phthalic anhydride. A solvent for nitrocellulose. It is the most frequently used plasticiser in lacquer manufacture.

**DIELECTRIC STRENGTH.** Non-conductive capacity, transmitting electric force by induction.

**DIETHYLENE GLYCOL ETHYL ETHER.** See *Carbitol*.

**DIETHYL OXALATE.** A nitrocellulose solvent which is prepared by the reaction of ethyl alcohol and oxalic acid. Used to some extent in lacquers but because it has very little solvent power for resins, its use is rather restricted.

**DIETHYL PHTHALATE.**  $[\text{C}_6\text{H}_4(\text{COOC}_2\text{H}_5)_2]$  A nitrocellulose solvent which due to its high boiling point falls into the plasticiser class. Prepared by the reaction of ethyl alcohol with phthalic acid.

**DIFFUSED LIGHT.** Permitting good circulation of light.

**DILUTION RATIO.** Ratio by which a given solvent or solution may be diluted without hazardous effects.

**DILUENTS.** In the manufacture of nitrocellulose lacquers certain volatile liquids which are not solvents for nitrocellulose are used to lower the viscosity and give certain other desirable properties. These materials as a class are called diluents. Diluents may be solvents of gums at the same time they are non-solvents of nitrocellulose and therefore often serve an excellent purpose in holding gum solutions in mixtures with nitrocellulose solutions.

**DIMETHYL KETONE.** ( $\text{CH}_3\text{COCH}_3$ ) See *Acetone*.

**DIMETHYL PHTHALATE.** [ $\text{C}_6\text{H}_4(\text{COOCH}_3)_2$ ] A water white to light straw colored liquid — used as a plasticiser in cellulose acetate and plastics.

**DIPENTENE.** A water white liquid constituent of turpentine. Has a boiling point of  $176^\circ\text{C}$ . Finds large usage in synthetic enamels.

**DIPPING.** The process of applying finishing materials by immersing an object to be coated. Also used as an adjective to designate the method of application; such as, a dipping lacquer, that is, one to be applied by dipping, etc.

**DIPPING MACHINE.** A mechanical contrivance used in dipping (by immersion) small articles. Controlled for slow or rapid withdrawal and permitting heavy one-coat finishing operations.

**DIPROPYL KETONE** (*Butyrone*). [ $(\text{CH}_3\text{CH}_2\text{CH}_2)_2\text{CO}$ ] A colorless liquid used in lacquers as a high boiling ketone.

**DIRT NIBS.** Small specks of foreign material in the dried film of finishing materials are called dirt nibs. They should be removed by sanding or by rubbing with pumice stone and water before the next coat is applied.

**DIRTY.** Not clean, just as the term applies. When speaking of colored lacquers, the term may mean also that the color is not clear or bright, that is, a muddy color — not referring to dirt at all.

**DISCOLORATION.** The change, through usage or element subjection, from an original color.

**DISPERSION.** A very fine suspension or a colloidal solution.

**DISTEMPER COLORS.** A color ground or mixed in water with the addition of a small amount of binding substance. Used chiefly for graining purposes when imitating the grain of wood on metal or such surfaces. Stale beer was formerly used as a binder in these graining colors. A substitute for stale beer can be made by heating a gallon of water to the boiling point and slowly stirring in one-half pound of dextrine. Let stand until cool and make sure all the dextrine has been dissolved. Use as thin as possible to do the work. Solutions of casein are sometimes used as binding agent in graining colors of this sort.

**DISTILLATE.** Any condensed product produced by cooling the vapors of a material that has been heated sufficiently to cause a part of it to go off in vapor form.

**DISTILLING RANGE.** The recorded thermometer range with and by which a liquid is distilled.

- DISTILLATION.** The act of applying heat to drive off certain portions of a material in vapor form.
- DISINTEGRATION.** The complete breaking down of the dried film of a finishing material is spoken of as disintegration. It may be caused by long continued exposure to the weather or to the improper type of finishing material being used for the work in hand.
- DOCTOR TEST.** This is a test used to detect the presence of sulphur in petroleum distillates. It depends upon sodium plumbite being darkened by sulphur.
- DOPE.** The familiar name for a cellulose nitrate or cellulose acetate lacquer used to coat the fabric of airplane wings to make them taut. Also used for other lacquers to be used for special purposes, such as leather dope, etc. A concentrated nitrocellulose lacquer base is oftentimes referred to as a dope base.
- DOPE COTTON.** Designation of high viscosity nitrocellulose, i.e., 20–30 second, 40 second and 70 second nitrocellulose.
- DRAW.** Resistance, as in the case of dragging of brush. Setting up is too rapid so that the action of the movement of the brush is retarded.
- DRAGON'S BLOOD.** A dark red gum which is exuded from the fruit of a species of trees in the Malay peninsula. Formerly used for its peculiar red coloring properties in lacquers. Not a permanent color.
- DRAUGHT TEST.** A test sometimes applied to finishing materials just after they have been applied and before they are dry; by subjecting them to a current of air.
- DRAWOUT.** When it is desired to determine the undertone of a color a small amount is placed on a glass slide and scraped thin or smudged before being inspected. Also used to determine the fineness of pigment grind. This is called a drawout.
- DRIERS.** The salts of certain metals hasten the drying action of oils when added to paints or varnishes. These compounds are known as driers. Some driers are in the dry form, others are in the paste form, but most of them are solutions of metallic salts in oils and volatile solvents with or without the presence of gum resins. These solutions are known as driers, oil driers, japan driers, liquid driers and japans. The action of driers in oils is not thoroughly understood, but they are thought to act as catalytic agents carrying oxygen from the air to the oils. The metallic salts most commonly used are those of lead, manganese and cobalt. Also see *Liquid Driers*.
- DRIPS.** The small drops of material which remain on the dripping edge of dipped work and dry there are known as "drips," "drip points," or "tits." See *Tears*.
- DROP BLACK.** A black pigment made from calcined animal bones. Drop black does not have very strong hiding power, due to low amount of carbon present. Also termed "*Cosmic Black*." A typical analysis of drop black is:

|                         |     |
|-------------------------|-----|
| Carbon .....            | 11% |
| Phosphate of Lime ..... | 78% |
| Carbonate of Lime ..... | 6%  |
| Silicates .....         | 3%  |
| Moisture .....          | 2%  |

**DRY.** Correctly speaking, a material is dry when it is free from liquid. Paint, varnish and lacquer raw materials, whether liquid or solid, are said to be dry when they contain no uncombined water. In speaking of paint, varnish or lacquer films, they are said to be dry when they are completely solidified.

**DRY SPRAY.** This term is referred to if in spray applying a finish it is not given a full wet coat and spray specks appear on the surface.

**DRY TO HANDLE.** A film of finishing material is dry to handle when it has hardened or solidified sufficiently that the coated object can be handled without the finish coming off on the hands or being seriously damaged.

**DRY TO TOUCH.** When a film of finishing material has solidified sufficiently that it can be touched lightly without any of the finish adhering to the fingers it is dry to touch. Not thoroughly dry but dry to handle.

**DRYERS.** See *Driers*.

**DRYING.** The act of changing from the liquid to the solid state of evaporation of the volatile thinners and by oxidation of the oils.

**DRYING SPEED.** The rapidity or time involved in a wet coating drying.

**DRYING OF PAINT AND VARNISH.** The following information regarding the mechanism of paint and varnish drying is taken from the Bureau of Standards, Circular No. 69, entitled "Paint and Varnish."

"The process which occurs when a film of paint or varnish dries depends primarily upon the nature of the vehicle. Water paints, such as whitewash and calcimine, and spirit varnishes, such as shellac in alcohol, dry by simple evaporation of the volatile liquid, this being water in the case of whitewash and calcimine, and alcohol in the case of shellac. The drying of oil paints and varnishes, however, is quite different and, in order to understand this, attention must be drawn to certain peculiarities of the so-called drying oils.

"Suppose four plates of glass are coated, one with a thin film of water, another with gasoline, another with a heavy mineral oil, and still another with linseed oil, and all four plates are exposed to the air for several days. The water and gasoline will evaporate and leave the plates dry and practically in the same condition in which they were before applying the liquid. The plate covered with the heavy mineral oil will be found to be greasy and in practically the same condition as immediately after the oil was applied. The plate covered with linseed oil will also have a coating on it, but this coat will first become 'tacky' and finally get to a hard varnish-like film. If this experiment is tried with other vegetable oils, it will be found that some of them, olive oil for example, behave very much like minerals; that is, show only a very slight tendency toward the formation of a varnish-like coating. Other oils, such as those of corn and soybean, will behave in a manner similar to lin-

seed oils; that is, become a more or less tacky mass, with perhaps the final formation of a varnish-like material.

"Oils which behave like linseed oil are called drying oils. It will be seen from this illustration, however, that the term 'drying' as applied to such oils is not similar to the drying which takes place on the exposure of a material, wet with water, to dry air. The drying of a substance wet with water is simply the removal of the water by evaporation.

"The drying of a drying oil is caused by the change taking place in the liquid, which change is accompanied by an absorption of oxygen from the air. It is hastened by dry weather and sunlight, and is also accelerated by the presence of certain substances known as driers, which will be discussed later."

**DRYING OILS.** Those oils which dry to a varnish-like film upon exposure to air and sunlight. Linseed oil, chinawood oil and perilla oil are the three principal vegetable oils of the drying class used in paint and varnish manufacture. Menhaden or fish oil is the only animal oil of the drying class that is suited to the requirements of the industry.

**DUCO.** This term is frequently used erroneously in the generic sense. It is actually the trade name of lacquer products as manufactured by the du Pont company.

**DUCTIBILITY.** (Latin, duco, lead) The capacity for deformation or extension without rupture by drawing or other process involving tension. A property of low yield value, fairly low mobility with adequate cohesion. (Journal of Rheology.)

**DULL FINISH.** A lustre less than a full gloss, usually almost a dead flat.

**DULL RUBBING.** The act of rubbing a dried film of finishing material to a dull finish, usually with pumice stone and oil or water. See *Rubbing* and *Polishing* for further details.

**DURABILITY.** The life of the finishing material under actual wearing conditions, whether inside or outside. If a finishing material retains its hardness, elasticity, toughness and other properties without the appearance of checks, cracks or other defects, over a long period of time it is said to be very durable. Durability, then, is an expression of the resistance offered to a change in appearance or in other important properties.

**DUST.** One of the size gradings of various gums, being composed of very small pieces, almost as fine as dust.

**DUST FREE.** When a film has dried so it will no longer allow dust to penetrate and stick to the finish, it is said to be dust free.

**DUTCH METAL.** Thin leaves of bright brass which are used for over laying similar to gold leaf.

**DYING AWAY.** See *Deadening*.

**EARTH PIGMENTS.** Those pigments which are mined from the earth or occur naturally in such form as to be readily used without any extended manufacturing operation which might change their chemical composition.

Ochre, Umber, Sienna and Van Dyke Brown are some of the most important earth pigments. All earth pigments are very permanent and are not easily affected by alkalis, heat, light or moisture. They are used considerably in the manufacture of paste wood fillers and also for tinting, staining and graining.

**EAST INDIA GUM.** A gum resin in two grades — pale and black — which comes from Singapore. It is said to be nothing more nor less than fossilized dammar. Used to some extent in the manufacture of flat lacquers.

**EFFLORESCE.** To form or become covered with a powdery crust. Interior brick walls and similar surfaces are said to effloresce when they become covered with a powdery substance.

**EGG SHELL LUSTRE.** A material is said to have an egg shell lustre when it dries to a finish that closely resembles the appearance of an egg shell — with respect to lustre.

**ELASTIC.** The property of returning to the original shape or volume after the distorting force has been removed.

**ELASTICITY.** A material has elasticity when it has the property of being elastic. In films of finishing material, the elasticity is the amount of strength they can undergo without breaking, or the ability to change size or shape repeatedly without breaking. Elasticity and toughness are considered almost interchangeable although toughness is more rightly the resistance to breaking or the ability to stand great stresses without breaking.

When substances have been compressed they tend to recover their volume as soon as the compression is removed. All fluids have perfect elasticity of volume. Elasticity of shape refers to spontaneous return of a substance after deformation to its former shape. The term is used in two distinct senses. According to one, a substance is highly elastic which is easily deformed and quickly recovers, that is, it depends upon the amount of the deformation or recovery. According to the second usage that substance is the deformation. Elasticity should be measured according to the first definition, and the lack of perfect recovery used to calculate the plasticity.

Quantitative: Elasticity of volume is measured by the compression in cubic centimeters of one cubic centimeter of material by a pressure of one dyne per square centimeter. The elasticity of shape is measured by the displacement in centimeters given to either of two parallel planes, one centimeter apart, by a shearing stress of one dyne per square centimeter, the space between filled with the elastic material. The reciprocal of *Rigidity*.

**ELASTIC LIMIT.** The elastic limit of a material is an expression of the maximum stress of distorting force it can stand and still return to its original size after the force is removed. When the force is great enough to stretch the material to a point where it does not recover, the elastic limit is said to be exceeded.

**ELEMI GUM.** An aromatic, balsamic, resinous gum resin of modern origin which is obtained from certain trees allied to the *Amyria* family. Used in the manufacture of some lacquers because of its elasticity and adhesive properties.

- EMULSIFYING AGENT. A substance of chemical nature which when added to a solution or liquid permits a condition of suspending; especially advantageous in adding materials of heavy nature and preventing pigment settling. Triethanolamine is a very good emulsifying agent.
- EMULSION. A liquid preparation in which minute particles of another liquid, which is ordinarily not miscible with the first liquid, remains in suspension.
- ENAMEL. A special type of colored finishing material made by grinding or mixing pigments with lacquers or varnishes. Lacquer enamels are clear lacquers into which have been incorporated colored and ground pigments. Any finishing material to which pigment has been added may be considered an enamel. Enamels may dry with a gloss, semi-gloss or dull finish.
- ENAMEL COAT. Pigmented coating as applied onto a given surface is usually referred to as an enamel coat.
- ENAMELED SURFACE. An improperly dried surface which shows a fine goose-fleshed effect. Silking in some cases is an incipient stage of enameling. Some of the causes are application in hot, humid weather, too long continued brushings and use of improper reducing materials.
- An enameled surface is also a surface to which enamel has been applied.
- ENAMELING. See *Enameled Surface*.
- EOSIN. A deep red organic compound sometimes used as a pigment when precipitated on orange mineral or red lead. Not permanent to light and easily fades.
- ESSENTIAL OILS. Those oils which contain an essence or have an odor similar to an essence. Some of the essential oils are: Cedar oil, oil of myrbane, oil of lemon grass, camphor oil, etc. They are used in lacquers to give a pleasing odor to such products containing secondary or tertiary solvents. Also used in conjunction with polishes. Turpentine is the most familiar essential oil, especially so in the paint industry.
- ESTER GUM. An artificial gum resin made by the combination of gum resin, such as rosin, with an alcohol, such as glycerine, at moderate temperature and sometimes under pressure.
- ETHYL ACETATE. ( $\text{CH}_3\text{COOC}_2\text{H}_5$ ) Ethyl acetate is a solvent for nitrocellulose and is used quite extensively in the manufacture of lacquers. It is made from ethyl alcohol and calcium acetate or concentrated acetic acid or it may be made from ethyl alcohol and dilute acetic acid or vinegar by a special process.
- ETHYL ALCOHOL. ( $\text{CH}_3\text{CH}_2\text{OH}$ ) Produced by the distillation of fermented grain or similar substances containing sugar or molasses. It is not used extensively in the industry, except for special purposes, until after it has been rendered unfit for beverage purpose by the addition of denaturants. It is then known as "denatured alcohol."
- ETHYL LACTATE. [ $\text{CH}_3\text{CH}(\text{OH})\text{COOC}_2\text{H}_5$ ] One of the most powerful solvents known for nitrocellulose and at the same time also a solvent for many gums. Made by a reaction between ethyl alcohol and lactic acid.
- ETHYLENE GLYCOL ETHYL ETHER. See *Cellosolve*.



**EXPANSION.** To enlarge, i.e., when moisture is present in wood.

**EXTENDER.** An inert pigment used as a bodying pigment to diffuse or dilute other colored pigments.

**EXTERIOR COAT.** The outside coat, e.g., the last coat in house painting.

**FADE.** In paint or coating technology, the term fade is used to indicate a change in color where and when such an applied coating has been subjected to such actions as sunlight. It is a dying away or "bleaching action."

**FADING TEST.** A test to determine the fastness to light of a color. Usually made by covering a portion of a sample with some opaque materials and exposing the entire sample to daylight, sunlight or an artificial light which emits artificial rays. By comparing the color on the covered portion with that of the uncovered portion, the degree of fading can be determined. Such machine devices as Fadometer and Weatherometer enter largely into fading tests.

**FADOMETER.** An instrument in the form of a carbon arc light to which is subjected coated objects (wood or metal). This device is used to simulate the action of sun's rays in a manner of hastening deterioration and/or disintegration of a subjected coating film.

**FAHRENHEIT.** The temperature scale in which 32° denotes the freezing point and 212° the boiling point of water.

**FALSE BODY.** Appearing to be very heavy consistency and giving the impression that a thick film will be deposited upon drying, whereas the opposite is the case. In other words, a lacquer has a false body when the viscosity or consistency is greater than would ordinarily be expected from an examination of the viscosity of the component parts. Due to the heavy consistency, false bodied lacquers or such finishing materials often must be reduced considerably before application, and consequently dry down to quite a thin film after being applied.

**FAST TO LIGHT.** A color is fast to light when it does not fade or change color upon continued exposure to strong light.

**FAST SCHEDULE.** Generally associated with a lacquer schedule where the coating drying is more rapid than a varnish schedule.

**FAT.** Very plastic or capable of becoming so on the addition of a dispersing agent.

**FATTY.** When a paint, varnish or other finishing material has bodied up with age so that it no longer dries as well as it originally did, it is said to be fatty.

**FATTY ACID.** The acid which is present in fats or oils in combination with glycerine. As the fat breaks down some of this fatty acid is liberated and small quantities of it are usually present in the free state. Fatty acids are entering into the recent paint trend in that the fatty acids of certain oils are basic raw materials for synthetic resinous compounds.

**FATTY EDGE.** The thick edge left on work by the dipping or flow-coating process, where the material dries with a rounded thicker film, due to the surface tension not allowing the material to flow off clean.

FEATHERING. This term is used in motor car finishing when rubbing or sanding down a surface to a feathery edge, that is, when one coat of material is made gradually to become thinner around the edge until it finally disappears. The term also is applied where the coating is drawn out to a very thin film at the edges when applied.

FERRIC FERROCYANIDE. See *Prussian Blue*.

FERROUS SULPHATE. More commonly known as copperas. When mixed with prussiate of potash under certain conditions *Prussian Blue* is formed.

FILLER. A filler is a material, usually containing considerable quantities of pigment used for building up, or filling the imperfections in the surface to be finished. Iron fillers and wood fillers are the two main types of fillers, the first being used to smooth rough iron castings, etc., and the second to fill the pores of open pored wood.

FILLER TROUBLES. Such conditions as filler heaving or bleeding when coating materials are applied are referred to as filler troubles.

FILM. A layer or application of applied coating material.

FILM-O-METER. A machine used to determine the stress-strain of films and records the weight of mercury required to rupture the film as clamped between two rings.

FILM PREPARATION. The act of preparing a film or thin layer of coating material (usually on glass or an amalgamated surface) for test purposes.

FILM SCRAP. Reclaimed scrap photographic film after the picture and emulsion have been cleaned from it. This cellulose material finds common use as the cotton constituent in lacquer manufacture.

FILM SPINNING DEVICE. A machine device for evenly coating by whirling or spinning a lacquer or similar film onto a surface for further testing.

FILM THICKNESS. The amount or thickness of lacquer or similar material applied onto a given surface.

FILTER PRESS. A machine consisting of several flat plates and chambers with filter cloth or filter paper between each adjacent set of plates and held tightly in contact with each other by strong pressure. The lacquers or varnishes to be filtered are forced through the filtering medium by means of pump arrangement and the solid matter is deposited in the chambers, leaving the liquid clear and free of solid particles.

FINENESS. A term used to denote the extent of subdivision. It is expressive of the number of particles of pigment in a unit volume.

FINGER NAIL TEST. A physical test upon a dried surface to indicate brittleness or film strength.

The quartz finger nail test is one in which weights drive a quartz rod into a film. The diameter of impression is measured by micrometer. Hardness is expressed by the weight needed to puncture the film and create an impression.

- FINISH COATER.** The last applied film of coating material to constitute a finishing schedule.
- FINISHING LACQUER.** A term used to denote a coating of lacquer applied to a surface for finishing purposes. Usually allied with the last coat application of lacquer on motor car surfaces. Such products are usually clear lacquers which are so constructed as to produce excellent leveling by spray gun application. Such lacquers are resistant to the elements.
- FINISHING SCHEDULE.** The time between the number and kind of applications required to coat an object. Also the operations involved in a finish.
- FIRE CRACKING.** A term used when the finish has been exposed to heat so as to cause delicate intricate and almost invisible surface cracks to form. Most frequently allied with paints and varnishes.
- FIRE FOAM.** A carbon dioxide froth which is an effective fire extinguisher.
- FIRE POINT.** The temperature at which a material takes fire and continues to burn until entirely consumed (or extinguished) when exposed to a small flame. See *Flash Point*.
- FIRST COATER.** A first coater is any finishing material used as the first coat over the wood or metal surface. There are dipping and baking first coaters for use on fenders and similar metal parts and there are clear and pigmented first coaters for use on wood, which aid in filling the pores of the wood and in reducing the cost of finishing. In this respect see *Liquid Fillers*. First coaters are opposite to finishing coaters. Also see *Bond Coat*.
- FISH OIL.** Commonly *Menhaden Oil*. The only animal oil used to any extent in the paint and varnish industry. It is used to some extent in paint reducing compounds, baking japans, and in those products which are required to stand a good high heat test.
- FIXED OIL.** An oil of a stable, saturated nature, not easily broken down. Fixed oils usually do not readily absorb oxygen and are therefore non-drying oils.
- FLAKING.** A term used when the coating does not knit properly to the underneath surface, causing the finish to chip off the work by breaking into small pieces and falling off. See *Scaling*.
- FLASH POINT.** The temperature at which a material will momentarily take fire or flash when exposed to a small flame. See *Fire Point*.
- FLAT.** A term used to designate a finish which has no lustre or gloss.
- FLAT LACQUER.** A lacquer which upon drying gives the appearance of having been rubbed. See *Satin Finish*.
- FLAT MILL.** A type of grinding mill most generally used to grind pigments. It consists of two stones, the upper one of which is stationary while the lower one revolves.
- FLAT PAINT.** An interior paint which dries to a flat finish.
- FLEXIBILITY.** The determination of elasticity of a given film. The act of being flexible or pliable.
- FLOATING.** See *Color Float*.
- FLOCO.** See *Flow Coating*.

- FLOOD.** A lacquer is sometimes said to be flooded onto the work when it is applied very liberally. The term flooding also describes the change in color of a finishing material after it is applied to the work due to color float.
- FLOURING.** Another term for *Powdering*.
- FLOW COAT.** Either a coat applied by the flow-coating process or the final coating applied to a surface in a very free manner which will permit the material to flow freely.
- FLOW COATING.** The process of applying finishing materials with a flowing machine, by which the product is flowed from a hose-like arrangement and the excess is allowed to run off into drip pans.
- FLOWING.** An adjective used to designate the method application of a material. Also used to designate the leveling action of a lacquer, such as flowing out smoothly, not showing sags if on upright work, as after being applied by spraying.
- FLOWMETER.** An instrument for measuring the amount of flowing properties in a finishing material after it has been applied and before it sets up or dries.
- FLUID.** (Latin; fluo) Any material, either a gas, a liquid or a very soft solid, that is capable of flowing.
- FLUIDITY.** The measure of the rate with which a fluid is continuously deformed by a shearing stress. The property of flowing freely.  
Quantitative: The fluidity is measured by the relative velocity in centimeters per second imparted to either of two parallel planes one centimeter apart by a shearing stress of one dyne per square centimeter, the space between the planes being filled with the fluid, the unit of measurement is the rhe. (*Journal of Rheology*.)
- FLUX.** Any material which is heated with another one to cause it to soften or become more fluid at a lower temperature, is a flux.
- FOOTS.** Slimy, gelatinous matter separated from oil on standing.
- FORCE DRY.** Any means of hastening the drying action of an applied coating—usually referred to as *Baking*.
- FORD CUP.** A viscosimeter used to determine the viscosity or body of a lacquer at a given temperature.
- FOSSIL GUM RESINS.** Fossil gums are the so-called “copals” or “hard gums” which were exuded from living plants centuries ago in the form of liquids or semi-solids, which have lain in the ground for centuries and thus hardened or fossilized with time. Some of the fossil gum resins are: Amber, Zanzibar, Kauri, Manila, Pontianak and Congo. See *Gum Resins*.
- FOUR-HOUR FINISHES.** “Synthetics”—containing synthetic resins—which dry in approximately four hours.
- FOXY.** When certain types of finishing materials are applied by brushing and viewed at different angles to the course of the brush they show different shades of color due to the pigment crystals being arranged in a different order. Such a material is called foxy.

**FREE FLOWING.** Without retardation. A material is said to be free flowing when it shows freedom of brush marks, sags, etc.

**FRENCH POLISH.** One of the oldest methods of finishing wood consists of applying an alcohol solution of shellac with a soft cloth ball on which a few drops of drying oil, such as linseed oil, have been placed, and continuing to rub while the solution dries. The finish thus produced is called a French polish and the act of producing the finish is called French polishing.

**FRESCO COLOR.** The water paints used for wall decorations are sometimes called Fresco colors.

**FROSTING.** Another term for crystallizing. Also used to express the use of contrasting colors in wiping or blending on top of finished work to give a two-toned effect, especially in finishing reed and fibre furniture. The frosting color remains in the depressions while the base color shows on the raised portions. This term is also applied to a decorative coating made of powdered mica.

**FULL COAT.** A full coat is usually referred to as a complete scheduled application, indicating surface coverage.

**FULL DRYING.** A material is said to be full drying when it dries out with a full body or thickness of film on the work and shows a great depth of finish.

**FULLER'S EARTH.** A type of earth or clay used to aid in the bleaching and filtering of oils and similar substances.

**FULLNESS.** A term used to denote the amount or depth of finish on the work. A lacquer having a heavy coating on the work in minimum applications, is said to have fullness on the work.

**FUSEL OIL.** An oily acrid liquid consisting of the higher alcohols and other similar materials which are produced in smaller quantities at the same time ethyl alcohol is produced by the fermentation of grain.

**FUSIBLE STATE.** The state of being capable of being fused. (Liquified by heat.)

**GALLON.** In the United States a standard gallon is 231 cubic inches, or the volume of 8.33 pounds of water. The Imperial gallon, used in Canada and the British Empire, is 277.44 cubic inches or the volume of 10 pounds of water. Since the volume of all liquids changes with temperature, the temperature at which the volume is to be measured should be specified.

**GALVANIZED IRON.** Galvanized iron consists of sheet metal which has been dipped in hot zinc, producing the familiar large crystals or spangles of zinc on the surface as the zinc cools. Galvanized iron surfaces always have a greasy feel and more or less trouble is experienced in making finishing materials adhere to zinc or galvanized iron surfaces.

Weathered galvanized iron holds finishing materials better than new galvanized iron, probably due to the reaction of oxygen in the air with small traces of chemicals in rain water to form zinc salts which have a rougher surface than new zinc. This weathered condition can be produced artificially by the use of various chemical washes to remove the grease and form

a coating of zinc chloride or other zinc salts to which finishing materials adhere better than to plain zinc surfaces.

Some of the zinc or galvanized iron washes used are:

- (1) Vinegar or weak acetic acid.
- (2) One part of commercial hydrochloric or muriatic acid to four parts of water.
- (3) 12 oz. copper chloride.  
12 oz. copper nitrate.  
4½ gal. water.  
12 oz. hydrochloric acid.  
Mixed in given order.
- (4) A weak solution of ammonia.
- (5) 6 oz. copper acetate.  
1 gal. water.

These solutions should be mixed and kept in glass or earthen vessels and applied with a brush. After the solution has dried the work should be washed with water, dried and coated as soon as possible afterward.

**GAMBOGE.** A yellowish gum-resin obtained from a tree in Siam, which is water soluble. Used as a water color. Not used in lacquers.

**GANG.** The ordinary rubbing stone or brick is too rigid and inflexible to be used satisfactorily in rubbing many objects, especially where there is any curvature to the surface. Automobile finishers often break up rubbing stone into small pieces and bind them together into a more flexible form. This is known as a "gang" or a "rubbing gang." A rubbing gang is usually made as follows: Place the solid brick in water overnight to make it soft and to prevent it from chipping too much while cutting it up. Then cut it into small pieces with the aid of a putty knife or some similar instrument. Now place about three rows of four pieces each, side by side and bind around and round with a half inch strip of cloth or adhesive tape after putting a handful of cotton waste on the top. This makes a nice pad that will fit the palm of the hand.

**GARDNER-HOLDT TUBES.** A series of accepted standard glass tubes filled with a non-changing liquid and used for comparison of viscosity or body.

**GAS BLACK.** Another name for the black pigment called carbon black. Produced by burning natural gas in an insufficient supply of air.

**GAS DISCOLORATION.** This term is usually expressed in connection with refrigerator and baking establishments where either refrigerant or baking fumes tend to discolor the applied coating.

**GEL.** A gelatinous mass produced by slow change, physical action, or by addition of saline substances to the solution of a colloid body—Kingzett. Certain varnishes gel or liver when mixed with certain lead or zinc pigments. Lacquers frequently gel when mixed and permitted to stand in the presence of bronze powders. According to Gardner, who describes apparatus for testing the strength of a gel, metallic soaps used for bodying and suspending purposes should gel readily, but for flatting purposes, gelling should be avoided.

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GELATINOUS. A material is said to be gelatinous when it has the consistency of a very soft elastic solid or gas the nature and appearance of gelatin.

GILSONITE. A black, coal like substance mined in Utah and other localities. Used as a gum resin in the manufacture of black asphaltum varnishes. See *Asphaltum*. Gilsonite is used to a small extent in lacquers, especially so for chassis black coatings.

GLARIMETER. An instrument used in the measurement of the gloss of coating materials.

GLASS GILDING. Applying gold leaf to glass on show windows for advertising purposes.

GLAZE COAT. A glaze coat in metal and automobile finishes is thought of as a coat of creamy consistency surfacing material applied with a putty knife. In furniture work a glaze coat is thought of as a thin coat containing a small amount of color to strengthen or richen the original color of the stain, filler or wood itself. Sometimes a glaze coat is also thought of as an antiquing or blending coat by which certain parts of the work are made to appear darker than others through the application of a thin coat of colored material so the resultant color is the combined effect of the ground coat and the glaze. Generally speaking, wherever the term may be found, a glaze coat is a thin coat.

GLAZING. The operation of applying any of the materials mentioned under *Glaze Coat* or the operation of setting window glass with putty. Also see *Antiquing* and *Highlighting*.

GLAZING KNIFE. A knife used for applying glazing putty. Several widths of glazing knives with various degrees of stiffness in the blades should be provided for applying putty and hard putty. A glazing knife should always be used with the same side up, since the edge soon wears to a level. This beveled side should always be used next to the body when applying glazing putty. Care should be taken to prevent getting nicks in the edges of the knife, so a smooth coat can be put on. The same care must be exercised in preventing the corners from becoming bent or rounded.

GLAZING PUTTY. A cream like consistency finishing material which is usually applied with a glazing knife, to fill scratches and imperfections in the surface of metal or wood. Glazing putty is usually applied somewhere between the primer coat and the last coat of surfacing material. After it is dry, it is sanded smooth before the next coat of finishing material is applied. Glazing putty formerly was made entirely of paint materials but now nitrocellulose basic putty is used exclusively in automotive finishing. Putty used in architectural work, wood and steel sash, etc., is based on raw linseed oil and whiting and may or may not contain white lead and/or special prepared oils for the more rapid drying and increased adhesion.

GLOSS. A term used to express the shine, sheen or lustre of the dried film. If a surface clearly and plainly reflects an image or light it has a high sheen.

GLOSSING UP. This term describes the condition when a dull rubbed surface takes on more gloss, due to the handling of the finished object.

- GLOSSMETER.** An instrument used to measure the gloss intensity of a surface.
- GLOSS RETENTION.** The act of retaining the original gloss or lustre. This condition is more properly termed "polishing up." Some people also use the term "glossing up" synonymously with "sweating."
- GLUTINOUS.** Having the consistency of glue, applied to a long, stringy substance. (Journal of Rheology.)
- GLYPTAL.** Trade name of synthetic resins of the glycerol-phthalic type.
- GOLD LACQUER.** A shellac with such a color that it will give the effect of gold when painted over aluminum leaf.
- GOLD LEAF.** A thin leaf of beaten gold, approximately 1/275,000 of an inch in thickness, used in all kinds of lettering and decorating. XX Deep (23 karat) is by far the most widely used, but 18 or 16 karat, known as lemon and pale, respectively, are frequently used in glass gilding to give a two-tone effect. It is $3\frac{3}{8}$ " square and is packed in books of 25 leaves each, 20 books to the "pack." Patent Gold Leaf is adhered to tissue paper where "loose" gold could not be handled economically.
- GOLD LEAF ROLLS.** Genuine Gold Leaf put between tissue leaf in rolls 67 feet long and any desired width up to $3\frac{1}{4}$ inches. It is used primarily for striping. Frequently called Roll Gold or Ribbon Gold.
- GOLD PAINT.** A mixture of bronze powder and liquid mixed ready to use for decorating where a temporary gold color is desired.
- GOLD SIZE.** A medium used to adhere aluminum, gold and palladium to surfaces. A size with a base of linseed oil, either with or without chrome yellow for coloring, is known as a slow size and can be gilded on the day after it is applied. Japan size, either with or without chrome yellow in it for coloring, is known as a "quick" size and can be gilded on an hour after applying.
- The procedure is to apply the size to those parts only where it is desired that the leaf adhere. Sufficient time is then allowed for the size to become sticky or tacky. The leaf is then applied and rolled or burnished flat against the surface. The excess gold size is removed, leaving the portions originally covered with the gold size now covered with the leaf.
- GOOSE FLESH SURFACE.** Meaning same as an "enameled surface." Having the appearance of goose flesh, with small, slightly raised, circular elevations all over the surface of the dried film.
- GOUGING.** One is said to gouge the finish in the rubbing process, when the surface is marred by the formation of gum on the rubbing pad. A surface may also be gouged by a sharp or blunt instrument striking it and chipping some of it from the underneath surface.
- GRAIN ALCOHOL.** See *Ethyl Alcohol*. Produced by the distillation of fermented grain or similar substances containing sugar or molasses. It is not used extensively today in the industry, except for special purposes, until after it has been rendered unfit for beverage purposes by the addition of certain denaturants that make it poisonous. It is then known as "denatured alcohol."

- GRAINING INK.** A colored ink or paint material used over a colored ground color to produce an imitation of the grain of various woods, such as oak, walnut or mahogany, or to imitate marble or other substances on metal, composition or wooden surfaces which do not naturally have the grain of the substance being imitated.
- GRAIN RAISING.** When water, acid or spirit stains or other materials which contain water and similar substances are applied to wood, the short broken fibres of the wood stand up or are raised due to having absorbed moisture. This is what is known as "raising of the grain" or "grain raising." It is overcome by applying thin coats of shellac over the stain which, when dry, stiffen the raised fibres and allow them to cut off smooth and sandpapered lightly. (Lacquer sanding sealers are also used to the same advantage.) Non-grain raising stains are now commercially available which overcome this objectionable feature.
- GRAIN SHOWING.** When a finishing material does not cover solidly and the grain of the wood can be seen through the finish, the grain is said to be showing.
- GRAINING TOOLS.** Hard rubber surfaces which are drawn over a wet coating to reproduce wood grain and similar effects.
- GRAPHITE.** A black pigment consisting essentially of carbon, obtained either from natural deposits or produced from coke in an electric furnace.
- GRAVITY.** See *Specific Gravity*.
- GRAY IN THE PORES.** When the paste wood filler does not dry hard or when insufficient or improper types of coloring matter are used in the filler, lacquer coats applied over it are likely to bleach out the coloring matter leaving the pores with a yellowish or grayish cast. When this condition is present the work is said to be gray in the pores. This gray appearance may also be caused by the pores not being entirely filled which allows small quantities of pumice stone slush to remain in them after the rubbing operation. When the oil or water has evaporated from the slush it shows gray. The two types of gray pores are readily distinguished since the first is underneath the film while the second is on top of the film and can be removed by proper cleaning methods.
- GRAYNESS AFTER RUBBING.** An expression in conjunction with furniture finishing. Usually caused by the finish being oil rubbed too soon after application. Best remedied by permitting greater drying time.
- GREASE RESISTING.** A coating showing no hazardous effects upon subjection to or with greases, butter, lard, fat, etc.
- GREASY.** Like grease or oil. Smooth, seemingly unctuous to the touch. Slippery. Talc and graphite have a greasy feel. The property seems to be caused by the layer of viscous fluid or soft solid particles, which forms the lubricating film between two surfaces sliding over each other.
- GREENING.** See *Greenish Cast*.
- GREENISH CAST.** A term used to express the greenish color which is sometimes noticed on wooden objects which have been finished with transparent material, especially when the work is examined in strong light.

Green cast may be due to the type of stain used, especially if applied too strong or to the paste wood filler not being cleaned off properly on spongy work or where the grain has been raised and not sanded off. In either case the filler clings to the surface of the wood and cannot be wiped off clean. Greening is not often found on solid, firm mahogany when the proper stain and filler have been used, and seldom shows on walnut or oak.

A dark varnish often accentuates the greenish cast formed by the stain or filler and in some cases varnishes actually have a greenish cast within themselves. It is said that rosin made from the last run of sap has a tendency to impart this greenish cast to varnishes because of the inclusion of chips, bark, etc., from the turpentine still. Tinting the varnish slightly brown, black or red has a tendency to counteract the greenish effect. Lacquers very rarely show this effect. See *Bluing*.

GREEN MATERIAL. A finishing material is said to be green when it has not been permitted to age or mature sufficiently after it is manufactured before it is used. Lacquers do not require aging before use.

GREEN TONER. A permanent green lake made from alizarine green.

GRINDING. The process of incorporating pigments into oils or similar grinding vehicle liquids and by passing this mixture between two closely adjacent surfaces or by similar means of reducing the size of pigment particles and insuring that they become thoroughly wetted with the liquid.

GRINDING VEHICLE. The liquid constituent used in the grinding of paints or enamels. The function is to "wet" the pigment and permit proper "slip-page."

GRITTY. A product is said to be gritty when the pigment is not ground sufficiently fine and shows up like small particles of sand on the work.

GROUND COAT. The coat of lacquer or similar materials applied under graining colors, to give the undertone to imitation wood and marble effect. Also the undertone under translucent glaze coats in producing antique glazed effects. Also used under such transparent colors as maroons to add undertone effect.

GROUND COLOR. A foundation coat of a color suitable for intensifying or helping the hiding power of more transparent colors applied over it.

GUIDE COAT. A coat of a different color from the other coats which serves as a guide in rubbing or sanding to help determine when a smooth surface has been reached. Also used in connection with applying.

GUM. The term "gum" is used in the industry to designate resinous materials used in the manufacture of lacquers and varnishes. A more proper term for these ingredients is "gum resin," since they are only primarily or not at all soluble in water. The correct definition of a gum is a "water soluble, amorphous substance exuded from plants and hardened upon exposure to the air."

GUM MASTIC. See *Mastic*.

GUM ROSIN. Rosin which is produced from the gum turpentine obtained by wounding living pine trees, as distinguished from the wood rosin obtained from the stumps and branches of dead trees. See *Rosin*.

GUM SPIRITS OF TURPENTINE. See *Gum Turpentine* and *Spirits of Turpentine*.

GUM TURPENTINE. The oleoresinous material obtained by wounding the living pine tree and which, upon distillation, yields (gum) rosin and (gum) spirits of turpentine, as distinguished from the wood rosin and steam distilled wood turpentine obtained from the stumps and limbs of dead pine trees.

GUMMING. Physical condition of abrading a surface of coating material with sandpaper, where coating coagulates the paper. Also applied when gum resin is added to coating materials.

GUN METAL FINISH. A lacquer finish usually arrived at by adding small amounts of silver lining bronze powder to a blue-black lacquer.

GYPSUM. A natural occurring form of hydrated calcium sulphate which upon being heated to remove part of the water of hydration forms the property known as plaster of paris. Further heating produces calcium sulphate which is one of the inert pigments that does not react and set in water as does plaster of paris. Gypsum is used in connection with nitrocellulose glaze coats to some extent. See *Terra Alba* and *Calcium Sulphate*.

HAIR LINING. A term used to describe very fine lines or checks on the dried surface of a finishing material, this being the forerunner of larger, more pronounced checking which is almost certain to show sometime later. Hair lines are probably caused more often by sudden changes of temperature, which if sufficiently severe and repeated often enough may cause the hair lines to develop into checks and cracks. Fine finished furniture should be properly protected with cotton flannel cover or newspapers, or some such material, during shipment in cold weather. The finished article should be moved gradually from one temperature to another, that is, it should not be subjected to any extreme change in temperature in a short space of time. Care should be exercised in transferring the finished work from a warm factory or warehouse to a cold shipping platform or box car. Equal care should be taken in bringing the article into a warm room from a cold atmosphere to prevent the condensation of moisture on the cold surface.

Sometimes minute hair lines apparently disappear when the varnish is warmed up again; in reality they are still there, however, and they become larger and more visible as time goes on—especially if the work is subjected to frequent changes in temperature.

HANUS NUMBER. The iodine number of oils and similar materials as determined by the Hanus method.

HARD GUMS. The so-called “copals” or fossilized gum resins which were exuded from living plants centuries ago. Some of the hard gums are: Amber, Zanzibar, Kauri, Pontianak, Manila and Congo.

HARDNESS. (Anglo-Saxon; heard.) A property applied to solids and very viscous liquids to indicate solidity and firmness in substance or outline. It is unyielding to a bruising, cutting or penetrating instrument. In viscous liquids the hardness of solids must be measured by the two properties of yield value

and mobility and there must be different kinds of hardness. Being a complex property, it is unfortunate that most of the methods in use attempt to express this property by a single numerical value. But it is at any rate recognized that the methods in use do not measure the same kinds of hardness.

In grading minerals the hardness is based upon the ability of one mineral to scratch another. This scratch hardness involves the factor of cohesion. The scleroscope hardness test depends upon the amount of rebound of a steel sphere dropped upon the surface to be tested and involves the factor of elasticity. Since very viscous liquids like pitch with complete absence of yield value and low tensile strength may yet possess a certain form of hardness, it seems reasonable to assume that a low mobility is essential and distinguishes hardness from toughness, since a tough substance may be deformed whereas a merely hard substance may or may not. Rigidity is sometimes regarded as a form of elastic hardness. (Journal of Rheology.)

The opposite of softness. That property of a lacquer or similar film to withstand denting or printing, or of resisting penetration by an outside object.

HARDNESS TESTER. A machine device employed to determine the hardness of a given film of lacquer or similar material.

HARD PUTTY. A paste material used for filling large imperfections in wood and metal while building up the surface. Usually applied with a glazing knife, and after being dried is sanded smooth before proceeding with application of finishing coats.

HEAT CONVERTIBLE RESIN. Usually referred to in conjunction with synthetics. These are changeable by subjection to heat to an infusible and insoluble mass.

HEAT RESISTING. A coating showing no hazardous effects upon subjection to elevated temperatures. Not to be confused with baking.

HEAT HARDENING. This expression is associated with baking and in most instances with plastic resins which, when subjected to heat, become hardened.

HEAT TREATING. See *Baking*.

HEAVING. If the building coats of finishing materials are applied too frequently or if these coats are applied too heavily or unevenly so as to prevent proper drying, the film dries at the top and will remain more or less soft and mushy underneath. When such a built up finish is rubbed, the top coat breaks through or "scales" in spots and these spots will be more porous or softer than the surrounding surface. The final or flow coat may sink into these spots, soften up the building coats and cause a slight swelling or raising of the surface in those spots. This is termed "heaving" or "kicking up."

HEAVY BODIED. A lacquer or similar material that has a thick consistency or high viscosity is said to have a heavy body.

HEAVY BODIED OIL. An oil thickened by heat or oxidation.

HERCOLYN. A water white viscous liquid resin and plasticiser used in lacquer for paper coatings.

HEXABROMIDE NUMBER. A number expressing the percentage of insoluble bromine compound formed by treating an oil with bromine, the most valu-

able indication of the quality of linseed oil, yet seldom used due to the difficulty of conducting this test.

HEXALIN. A colorless viscous liquid used as a solvent and partial plasticiser in nitrocellulose lacquers. Made from phenol.

HIDING POWER. The hiding power of a pigment or finishing material is a measure of its opacity or its ability to cover solidly over another color as to obscure or prevent the original color from showing through. If one pigment has greater opacity than another a smaller quantity of it will be required in a gallon of liquid to produce a solid coverage. A material containing a very opaque pigment will require fewer coats to obliterate the color of the wood, metal or previous colored surface than if a less opaque pigment is used. To test the opacity of a pigment as compared with another, rub up definite quantities of the pigment with definite quantities of the oil or grind them through a mill to obtain a paste product of usual consistency. An even coating of each product should then be applied over a board on which has been printed broad strips or squares of black and white. Any difference in opacity will show up. For spray lacquer, color opacity tests, the product is usually applied over surfaces previously coated with cream and black.

HIGH BOILING. Liquids boiling above 150° Centigrade are in this class.

HIGH FLASH (HIFLASH) NAPHTHA. A mineral spirits liquid with a high flash point (96° Fahrenheit) and a boiling range of 130°–180° Centigrade.

HIGHLIGHTING. One is said to highlight a piece of furniture or other finished object when he makes certain parts to appear lighter than the general trend of color for example by wiping some of the stain from the carved portions of a chair leg while the stain is still wet, so that part appears lighter in color when finished. It is usual practice to highlight by spraying a darker stain color over the finish and prior to the last coating of finishing lacquer. See *Antiquing* and *Shading*.

HIGH OIL ABSORPTION. See *Oil Absorption*.

HIGH SOLIDS LACQUERS. Lacquers made of maximum solids which produce great build on the work, usually above 30 per cent.

HIGH SOLVENCY THINNER. A volatile which has great solvent power and which will permit dilution to great extent with cheaper thinners.

HOLIDAYS. A term used for skipped or uncoated places on the work. See *Vacations*.

HUE. The quality of a color from which it derives its name is the hue or tone. It is sometimes used synonymously with the word "color."

HUMIDITY. The amount of water vapor in the air. See *Relative Humidity*.

HYDROCARBON. This term as used in the paint, varnish and lacquer industry is a classification of solvents derived from coal-tar and petroleum and containing carbon and hydrogen.

HYDROMETER. An instrument usually consisting of a long glass spindle weighted at one end with lead shot or mercury and bearing a scale for reading purposes, which is used for determining the specific gravity or Baumé readings of liquids. In the lacquer and allied industries most of these read-

ings are taken on the Baumé scale. The hydrometer reading is affected by the temperature of the material and consequently the temperature should be mentioned whenever a hydrometer reading is given. Since there are two Baumé scales, one for liquids lighter than water, the other for liquids that are heavier than water, the scale on which the reading is based should also be mentioned. See *Baumé*.

HYDROXIDE. A hydrated metallic oxide. A base. A compound which will give hydroxyl (OH) ions in solution.

HYGROMETER. This is not to be confused with the hydrometer mentioned above, but is an instrument which measures the degree of moisture in the atmosphere.

IMPACT RESISTANCE DEVICE. A machine device commonly called a "wood-pecker" where a hammer device strikes a coated metal panel specimen and automatically records when metal is struck, giving a numerical value.

IMPERIAL GALLON. The unit of volume measure used in Canada and the British Empire. It is the volume of ten pounds of water or 277.42 cubic inches. The standard United States gallon is 231 cubic inches or the volume of 8.33 pounds of water.

IMPROPER CLEANING. Wood or metal surfaces that are not cleaned properly, oftentimes the cause of finishing failures.

IMPROPER VENTILATION. In the drying room of an establishment or room where freshly coated lacquer, etc., surfaces appear, improper ventilation is sometimes the cause of filler troubles or spotty drying.

INDIAN RED. One of the iron oxide pigments, being practically pure ferric oxide.

INERTS. A term used for inactive pigments usually having little or no hiding or tinting properties when used in lacquers or similar materials. Inert pigments have been proven to be an advantage to paint when properly used. Not only do they reduce the cost of colors which are so strong that their use without reduction would be an extravagance, but also a reasonable amount of the proper inert pigments actually adds to the quality of a paint from the standpoint of durability and service. They are very chemically inert and are not effected in the least by ordinary atmospheric conditions, thus a reasonable amount of them actually reinforce and protect other pigments of a more active nature. The only deficiency of inert pigments is their lack of opacity or hiding power and if they are not used to a point that materially affects the hiding power of the paint they cannot be considered as adulterants, but are actually to be recommended.

INFUSIBLE. State of being not fusible or further changed by heating.

INFUSORIAL EARTH. See *Diatomaceous Earth*.

INGREDIENT. Constituent or part of.

INHIBITOR. A material which will prevent a chemical reaction from proceeding. Materials, the presence of which will prevent corrosion of metals. See *Corrosion*, see *Anticorrosive*.

- INITIAL COLOR.** Many colors fade on exposure and the reference is to the original color.
- INK.** A liquid or viscous material used for writing, printing, lithographing or graining. Many printing, lithographing and graining inks are made by grinding pigments in suitable varnishes and oils.
- INORGANIC COLORS.** Chemical colors resulting from the chemical combination of two or more inorganic chemicals; for example, chrome yellows (lead compounds) and Prussian blues (iron compounds).
- INSOLUBLE.** Not soluble or compatible with.
- INSPISSATE.** (Latin, in and spissum; thicken.) To increase to a desired consistency, thicken. Opposite to temper.
- INSULATING VARNISHES.** Cold cut solutions used for coating wires, coils, and electrical devices to insulate them electrically. Such products are termed varnishes.
- INTENSITY.** The intensity of a color is its purity of hue or color tone or the degree of hue as seen by the eye, as for example, an intense red is one which is seen as a very strong pure red color.
- INTERFACIAL TENSION.** Physical force which determines the nature of the boundary between two liquids when brought together.
- INTERIOR FINISH.** A finish intended for use indoors, e.g., wall and ceiling paints, furniture lacquers, etc.
- IODINE NUMBER.** Oils, waxes and resins have the property of absorbing iodine. It has been found that the percentage of iodine absorbed is fairly definite for each type of material and this iodine number is used as a basis of specifying and identifying products of a given quality. It also serves to indicate the capacity of drying oils to absorb oxygen from the air and, in conjunction with other tests, to determine the suitability of such oils for use in paint and varnish products.
- IRON BLACK.** The black oxide of iron.
- IRON BLUE.** Any blue pigment which depends upon its iron content for its blue color. Some of the iron blues are: Prussian, Chinese, Milori and Bronze Blue.
- IRON FILLER.** A heavy bodied lacquer or similar material containing large quantities of pigment and capable of quickly drying to a hard, tough, non-porous film which can easily be sanded to a smooth surface, used for filling the imperfections of iron, steel and other metals before finishing coats are applied.
- IRON MILL.** A paint mill consisting of a corrugated steel disc revolving tightly against a stationary steel shell. As the pigment particles pass between these moving steel parts the pigment is ground into the liquids.
- IRON OXIDE.** Oxide of iron. Occurs in nature as red oxide of iron and also as essential coloring pigment of sienna, umber and other earth colors. Also manufactured in a wide range of (synthetic) colors, red, yellow, black, etc.
- ISOPROPYL ACETATE.** $[\text{CH}_3\text{COO.CH}(\text{CH}_3)_2]$ A water white ester fluid used in lacquers, plastics, etc.

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IVORY BLACK. A high grade of drop black or bone black pigment. Formerly made by charring ivory.

JAPAN. There are three distinct classes of japan:

(1) Those varnishes which consist chiefly of a solution of metallic salts with a drying oil and thinner with volatile thinners, which are also referred to as "liquid driers," "oil driers" and "japan driers." These terms should be used in preference to the term "japan" for all such liquid solutions which are used for addition to oil varnishes, paints or enamels to facilitate drying.

(2) Those dark varnishes containing asphaltum, pitch and other similar materials which are used principally for producing a lustrous black finish on metal, wood, paper and other materials. They are divided into "air drying" and "baking" japans, according to the method of drying them after they are applied.

(3) Those liquids into which colors are ground to produce japan colors. Because of the variety of meanings, the word japan should be prefixed by an explanatory word such as baking japan, grinding japan, etc.

JAPAN COLORS. A colored paste material made by grinding fine colors in hard drying varnishes known as "grinding japans." Used extensively in the automobile and carriage trade for making color coats.

JAPAN DRIER. A liquid drier which contains enough gum resin to dry to a hard film with considerable coherence when used alone. Also used for additions to paints, varnishes and enamels to hasten the drying. This term should not be confused with "grinding japan" nor with "baking japan" which are defined elsewhere.

JAPANESE LACQUER. A varnish made from the juice or sap of a species of tree which grows in Japan. As it dries it becomes very hard or black. Black baking japans were first made to imitate the finished results produced with Japanese lacquer.

JAPAN WAX. A soft wax with a melting point of about 127°F. Obtained from sumac bushes which grow in Japan.

KAOLIN. One of the inert pigments found in nature and consisting essentially of a hydrated aluminum silicate. It has a tendency to impart easy brushing properties to products in which it is used. Very inert chemically being decomposed only by the most harsh treatment.

KAURI. A fossilized gum resin, exuded from the pine-like kauri tree in New Zealand centuries ago and now dug from the ground for use in making lacquers and similar products. In recent years kauri has come to be the most commonly used "hard gum" in high grade varnishes. The supply of this material is growing smaller and the price is increasing from year to year.

KAURI REDUCTION TEST. This is a test for quickly determining the comparative durability of a varnish by measuring its ability to withstand bending after being mixed with various proportions of a solution of kauri gum that has been carefully prepared to a definite standard of quality. The more elastic the varnish the greater will be the proportion of kauri solution that

can be added before a film of the varnish flowed on a bright tin panel and baked five hours at about 100°F. will crack when the panel is bent over a $\frac{1}{8}$ -inch rod.

KEROSENE. A medium boiling distillate from petroleum. Often referred to as "coal oil." Used only in baking products.

KETTLE BODIED OIL. An oil which has been heated to elevated temperatures, thereby taking on body or thickness.

KICKING UP. See *Heaving*.

KIESELGUHR. See *Diatomaceous Earth*.

KILN DRYING. A room or separate compartment with regulated heat, humidity and proper circulation of fresh air is often spoken of as a kiln. The drying of paint, varnish or even lacquer materials in such a compartment is known as kiln drying.

KNIT. A coat of finishing material is said to knit to another when the two coats cannot be separated or peeled apart after drying.

LAC. A modern gum resin which is the excretion of certain insects which feed upon the sap of a few species of trees in India and other far eastern countries. Shellac is the commercial form of "lac."

LACQUER. The term "lacquer" has been so abused that it is no longer possible to know exactly what type of material is being referred to without additional explanation at the time of using the term. Originally the term referred to quick drying thin bodied materials of all kinds, later it was applied to very thin oil varnishes, with or without color, which dried quickly; then to very quick drying spirit varnishes containing alcohol, benzol, acetone, amyl acetate and other quick evaporating solvents, with or without nitrocellulose, in combination with various gum resins. Later the term has been applied almost exclusively to spirit varnishes containing nitrocellulose, with or without gum resins in solution. It is best for clearness to refer to thin bodied varnish lacquers as "spirit varnishes" or "shellac substitutes" and to solutions containing appreciable amounts of nitrocellulose as "nitrocellulose lacquers."

LACQUER COLORS. Pigment colors ground in a compatible lacquer base which are intermixed with clear lacquer vehicles to an enamel finish.

LACQUER ENAMEL. A clear lacquer vehicle to which has been added pigment matter.

LACQUER OVER OLD FINISHES. In recoating, if and when lacquer is applied over an aged finish, it usually is a source of trouble. It is a good policy to either remove the aged finish or seal before lacquering.

LACQUER OVER OTHER FINISHES. A common source of trouble, especially lacquer over varnish.

LAKE. A lake is a pigment which is made by precipitating an organic dye upon a base of finely divided particles of inert, translucent pigment such as aluminum hydrate or calcium carbonate.

- LAMPBLACK.** A black pigment of a somewhat greasy nature made by burning coal tar distillates in an insufficient supply of air which produces a dense black smoke containing particles of carbon. The carbon is separated from the smoke and forms lampblack, which is practically pure amorphous carbon. A typical analysis is: Carbon, 99 per cent; ash, 1 per cent.
- LAP.** Used as a verb this word means to lay or place one coat of finishing material over or alongside of another coat so as to partly cover the first coat or project over or into the first coat, causing an increased thickness where the two coats are present as compared to the thickness of the single coat on either side of the lap. As a noun the word means that portion of a coat of finishing material which extends partly over a previous coat.
- LATEX.** The juice of plants from which rubber is obtained, usually of a milky color and consistency.
- LAUNDRETTE.** A washing machine used to coat small objects by whirling.
- LEAFING.** Bronze powders and similar pigments are in the form of thin flakes or minute sheets of metal. When such pigments are mixed with suitable bronzing liquids and applied to a surface these thin flakes float to the surface and overlap each other slightly. This action is known as leafing.
- LEAN.** Non-plastic, lacking the ingredient required to give the desired yield value; for example, pastry is lean when it lacks sufficient lard, that is, shortening. (Journal of Rheology.)
- LENGTH.** Length is a quality possessed by a solid having a low yield and a low mobility, ductile. A long substance has the characteristic of a very viscous liquid. It is capable of being drawn out into ropes, threads or fibres. Compare shortness, toughness and tackiness. (Journal of Rheology.)
- LET DOWN.** A pigment is said to be let down in color strength when it is mixed with a colorless, transparent or translucent mineral pigment, such as barytes.
- LEVELING OUT.** A finishing material is said to level out well if it flows out free from ripples, pock marks, orange peel or other defects after it has been applied by brushing, spraying, dipping or flowing.
- LIFE.** A term used to express the durability or period of time the film will remain elastic after being applied to the surface after finished.
- LIFTING.** When one coat of finishing material, upon being applied over another coat, softens and raises the undercoat in irregular wrinkles, the top coat is said to lift the undercoat. This defect is due to the solvent action of the freshly applied coat on the binder of the undercoat and is often seen in nitrocellulose lacquers applied over oil paint undercoats, especially when they are not dried by force to a hard film. The resultant defect looks much the same as the appearance of a varnished surface to which paint and varnish remover has been applied and allowed to dry. This defect is also known as raising.
- LINOLENIN.** The linolenic ester of glycerine, the most valuable constituent of linseed oil, of which it constitutes about 25 per cent.
- LINSEED OIL.** A vegetable oil, used to great extent in the paint and varnish industry. Obtained from the seed of flax, usually by pressure, either with or

without the application of heat. It is probably the most extensively used oil for making paint and varnish. It will dry, without the addition of metallic salts, in about three days when exposed to the air and the sunlight.

LINTERS. See *Cotton Linters*.

LIQUID. A liquid material is characterized by the free movement of the constituent molecules among themselves without the tendency to separate from one another as is the tendency in a gas. Liquids flow freely upon the application of a small force.

LIQUID DRIERS. These are essentially chemical compounds of certain metals (cobalt, manganese, lead, etc.) with organic acids. Driers containing high percentages of metal salts are known as concentrated driers. See *Driers*.

LIQUID FILLERS. First coat lacquers and similar materials for use on wood, which contain finely divided, transparent, inert pigments to aid in the filling of the pores of the wood and in the sanding properties of the material itself. The principal use of liquid fillers today is in the furniture industry. In this respect they are also termed *Building Coaters*.

LIQUID MASK. A liquid material which is applied over surfaces to which it is desired that finishing materials such as nitrocellulose lacquer do not adhere. Such a material can be wiped or peeled off afterward and has no injurious effect upon the surfaces to which it is applied. Used for covering windows and other parts of automobiles while applying nitrocellulose lacquers by spraying, also used as spray booth coating.

LITHARGE. (PbO) Yellow lead oxide. Used in our industry almost exclusively as a drier.

LITHOPONE. An artificial white pigment made by the mixture of solutions of zinc sulphate and barium sulphide. The precipitate consists of approximately the following: Zinc Sulphide, 30 per cent; Barium Sulphate, 70 per cent. Lithopone is very white and has good hiding power. Formerly it had the drawback of darkening upon exposure to light but this difficulty has now been overcome, and durable, permanent white products are being made from it. It is used largely in interior finishes, particularly flat wall paint, and, in combination with other pigments, in some exterior house paint formulations.

LIVERING. The coagulation of a finishing material into a viscous, ribbing, rubber-like mass. Usually occurs when products are mixed with other products of an uncontrolled nature, resulting in a chemical reaction. In other words, acidity has a certain bearing on the affinity of a product to liver. Some pigments have a tendency to cause livering; such conditions are exemplified by an acid condition in the structure of the lacquer or similar material. A well constructed lacquer seldom, if ever, livers in the can. Lacquers, however, will evaporate if exposed and may therefore thicken up slightly. This is not referred to as livering.

LIVERY. Having the consistency or the appearance of liver. The latter use is unscientific. Applied to certain materials such as lacquer, paints, etc., which sometimes develop an excessive yield value on standing. (*Journal of Rheology*.)

LONG. A finishing material is said to be long when it is quite elastic, due to the presence of large quantities of structurally proportioned plasticisers and/or plastic substances.

LONG OIL. A term used to express the amount of oil in a varnish; meaning that the proportion of oil to gum resin is great, usually above 25 gallons of oil per 100 pounds of gum resin. A long oil varnish is usually slower drying, tougher, more elastic and more durable than a short oil varnish. A spar varnish is a typical member of the long oil type.

LOSS OF FLEXIBILITY. When a drying material has lost its elasticity (usually through age) and breaks "short" it is said to have lost its "flexibility."

LOUSINESS. A very fine powdery float which is sometimes seen in clear varnishes, even after being filtered, when examined in a small test vial in a strong light. Sometimes refers to fine particles of lint present in nitrocellulose lacquers.

LOW SOLVENCY THINNER. A volatile which is slow in reducing and therefore has a low tolerance for cheaper thinners.

LUBRICANT. The opposite of abrasive. A substance used to reduce friction or to make surfaces slippery. The lubricant tends to eliminate the effects of asperities of the surfaces to prevent adhesion between the surfaces and to introduce a material, either solid or fluid, of sufficient consistency to maintain a film which can be easily sheared. (Journal of Rheology.)

LUSTRE. The gloss, shine or brightness of a finished surface is spoken of as its lustre. See *Gloss*.

MACHINERY FINISHES. Lacquers and allied materials used for finishing machinery are known as machinery finishes.

MADDER LAKE. A lake color made by precipitating the extract from madder root upon an insoluble metallic salt base. Now being superseded by alizarine lake, a typical analysis of which is: Alizarine, 35 per cent; Calcium Phosphate, 15 per cent; Aluminum Hydrate, 50 per cent.

MAGNESIUM SILICATE. A white inert pigment of little opacity. Produced from certain natural deposits which are a complex combination of silicic acid, magnesium and water of crystallization. Light specific gravity adds "fluffiness" to products in which it may be incorporated. Its softness makes it easy to grind to a fine surface. Sometimes used in heavy pigment products to suspend the heavier specific gravity pigments. See *Asbestine*.

MALEIC ACID. $[\text{COOH}(\text{CH})_2\text{COOH}]$ A solid fused mass used in the manufacture of synthetic resins.

MALEIC ANHYDRIDE. $(\text{C}_4\text{H}_2\text{O}_3)$ A white needle crystalline mass used in synthetic resin manufacture.

MANILA RESINS. Gum resins originating in the East Indies and used in varnish. This group includes soft, semi-fossil and fossil resins. They are spirit soluble, while the harder varieties are also used in oil varnishes.

MANJAK. A hard, black asphalt obtained from the West Indies.

- MARBLING.** When the grain and texture of polished marble imitated with finishing materials, this work is known as marbling.
- MARBLEIZING.** A finish involved in floating colors on water and dipping an object previously coated with a ground coat of lacquer, withdrawing slowly; thereby lifting the color with it and applying a clear lacquer finish overall.
- MASKING TAPE.** An adhesive coated crepe paper tape used to mask off certain parts of a surface not to be coated.
- MASTER STANDARD.** A laboratory standard which represents an approved product, color, etc., to which succeeding batches are matched.
- MASTIC.** An aromatic, astringent resin used in the manufacture of spirit varnishes to some extent. Sometimes called "gum mastic." Also known as "tear gum" from its peculiar shape.
- MAXIMUM TEMPERATURE.** The highest safe temperature referred to in a baking schedule.
- MELTING POINT.** The melting point is the transition point between solid and liquid phases. The melting point or the softening temperature of a colloid does not have the conventional meaning given above since it does not refer to a change of state but to a more or less rapid change in consistency. When a pure liquid like ethanol is cooled without crystallization, it becomes more and more viscous and finally vitreous, but it is quite arbitrary to speak of a definite solidifying temperature. With colloids, however, there appears to be a temperature at which the yield value appears and this may be regarded as the analogue of the melting point. The melting temperature and the solidifying temperature should be identical. In a colloidal solution the temperature of incipient melting and complete melting may of course be quite different. (Journal of Rheology.)
- MENHADEN OIL.** See *Fish Oil*.
- METAL PRIMER.** A metal primer is the first application as applied to an automobile or similar surface. It is a semi-transparent to opaque material of great adhesive properties. It is an expanding and contracting type of surface material.
- METALLIC BROWN.** A natural iron oxide pigment with an analysis about as follows: Ferric Oxide, 87 per cent; Silica and Silicates, 13 per cent.
- METALLIC SOAP.** The compound of any metal with any organic acid, such as the fatty acids of linseed and other paint oils. Metallic soaps may be formed in the varnish kettle or in the paint film, but the term is generally used to describe a group of manufactured products which are used as raw materials in the paint industry as driers, flattening agents or suspending agents, and in the manufacture of sealers and waterproofing compounds, etc.
- METHANOL.** (CH_3OH) The approved trade name for methyl alcohol. See *Wood Alcohol*.
- METHYL ACETATE.** ($\text{CH}_3\text{COOCH}_3$) A water white liquid used as a solvent for lacquers (nitrate and acetate).
- METHYL AMYL ACETATE.** [$(\text{CH}_3)_2\text{CHCH}_2\text{CHOHCH}_2\text{CHOH}_2\text{OCOCH}_3$] — Also known as *Methyl Isobutyl Carbinol Acetate* — a water white liquid used as a high boiling lacquer solvent.

- METHYL ALCOHOL. The chemical term for methanol or wood alcohol, which is obtained by the destructive distillation of certain kinds of wood. Methyl alcohol is poisonous, and consequently is little used in the lacquer and allied fields. See *Wood Alcohol*.
- METHYLENE CHLORIDE. (CH_2Cl_2) A colorless liquid used in lacquer manufacturing.
- METHYL ETHYL KETONE. A ketone solvent of great solvent power, used primarily in conjunction with cellulose acetate.
- METHYL ISOBUTYL KETONE. [$(\text{CH}_3)_2\text{CHOH}_2\text{COCH}_3$] A water white liquid used in lacquers as a solvent.
- MICA. A crystalline silicate of aluminum and other metals which is mined in America and elsewhere throughout the world. The crystals can be split into thin plates which are highly transparent and it is in this form that mica is commonly known. However, by-product mica from the electrical industry, which is imported from India because of superior quality and uniformity of color, is now being ground for use as a reinforcing paint pigment.
- MICRON. One thousandth of a millimeter.
- MILDEW. Chalky finishing materials exposed to warm damp conditions often develop a fungus growth, called mildew. In house paints it can be checked by the use of hard drying and toxic materials.
- MILKINESS. A term used sometimes in place of "muddiness." Also used to describe the appearance of a finishing material which has a white appearance, such as when moisture becomes mixed with lacquers.
- MILKING. In the use of varnishes on motor car finishes, the finishers, after flowing on the finishing coat of a varnish, allow it to flow and level out, then when nearly set up, run their fingers along the bottom edge of the job to remove the excess varnish that has accumulated as a heavy fatty edge. This is termed "milking."
- MILL BASE. Usually referred to as a pebble mill grinding base, which is generally incorporated with a clear vehicle to an opaque lacquer.
- MILORI BLUE. A soft, easily ground iron blue of a light shade.
- MILORI GREEN. A yellowish green pigment consisting principally of lead chromate.
- MINERAL OIL. Any oil derived from a petroleum base by distillation or otherwise.
- MINERAL SPIRITS. See *Turpentine Substitutes*.
- MINERAL TURPENTINE. See *Turpentine Substitutes*.
- MINIMUM TEMPERATURE. The lowest safe temperature referred to in a baking schedule.
- MISCIBILITY. The ability of intermixing or becoming a part of a combination, i.e., lacquer thinner is miscible with lacquer.
- MIST COAT. A very thin "fogged" coating as applied onto a given surface. May either be the first or last operation. Also used as a final coat operation, where it is a fully sprayed coat, on automobile surfaces to blend sand or scratch marks.

MIXING LACQUER. A lacquer used for mixing or blending purposes to impart certain additional desirable properties.

MOBILE. A material is mobile when it offers little resistance to flowing.

MOBILITY. (Latin: Mobilis, movable.) The measure of the rate with which a solid is continuously deformed after the yield value has been exceeded. The second quantitative factor is plasticity. Quantitative: The mobility is measured by the velocity in centimeters per second given to either of two planes one centimeter apart by a shearing stress of one dyne per square centimeter in excess of the yield value, the space between the planes being filled with the plastic material. Mobility is a more general term than "fluidity," the latter being the mobility when the yield value is zero.

MOBILOMETER. A machine device used to test the consistency of pastes or heavy bodied liquids.

MODIFIED RESINS. Just as strong pigments are frequently "let down" with inerts or extender pigments, synthetic resins are sometimes "modified" by the addition of ester gum or other resins.

MODIFYING AGENT. An added substance which brings about a change in form.

MOISTURE. For all practical purposes, moisture may be considered as very finely divided particles of water. Moisture in the form of steam or of a jet of water is sometimes used in a dry kiln to regulate the humidity. Moisture in lacquer causes blushing; in varnishes causes cloudiness; in lumber and wood it causes the raising of the grain; in baking japans it causes pitting. Moisture in paste wood fillers often causes bubbling when lacquers or allied products are applied over it. Moisture in the air line causes pitting, blushing and many other difficulties when finishing materials are applied to spraying. Too much moisture in the air causes lacquers to blush and retards the drying of same. Not enough moisture in the air causes "case hardening" or "top drying" in paints or varnishes. Too much moisture in finishing is a bad thing in general, causing many troubles.

MOISTURE CONTENT. An expression in percentage of the amount of water in lumber.

MOISTURE TROUBLES. The cause of lacquer coatings not adhering to a given surface may be directly attributed to presence of moisture. Oftentimes found in the spray line when the water trap has been neglected and permitted to fill up. To correct this condition, bleed the trap frequently.

MONKEY. A worthless mixture of resin and oil so completely polymerized in the kettle and solidified so that it is insoluble in molten resin, oil or thinner.

MONOETHANOLAMINE. [$(\text{CH}_2\text{CH}_2\text{OH}) \text{NH}_2$] A water white liquid used in polishes and for solvent emulsions.

MONTAN WAX. A hard, brown wax obtained from German lignites related to coal.

MUDDY. When the color of the work or the finish as a whole does not have a bright, clear transparent look, the finish is said to be muddy. A colored lacquer or allied product is sometimes said to be muddy in color when the

shade is not true to tone, but has a trace of brownish or yellowish color in it that takes away from the purity or brightness of the color.

MULLING. The act of thoroughly mixing pigments and liquids together either by hand, as in a pestle and mortar, or through an iron mill.

MURIATIC ACID. The commercial name for a dilute form of hydrochloric acid.

MUSHY. A finishing material is said to dry mushy when it does not harden through entirely, but remains soft and has little cohesive power. The material itself is mushy when it is soft and plastic.

NAPHTHA. A petroleum distillate having a low flash point, which is used to considerable extent in certain types of paints and varnishes. The naphtha usually used is heavier in specific gravity than benzine and lighter than most of the so-called turpentine substitutes. See *Benzine*, also see *Solvent Naphtha* (from coal tar).

NAPHTHYL BLUE. Dye used in coloring aniline lacquers. Readily soluble in regular solvents. Fast to light and is not affected by exposure to air.

NATURAL GUMS. That series of fossilized or annual gum resins which are natural products.

NAVAL STORES. The products of the pine tree chemical industry, e.g., turpentine, rosin, pine oil, tar, pitch, etc. In Colonial times the primary products of this industry were tar and pitch, which were used principally in caulking the seams of sailing vessels; hence the name which has persisted to the present day when turpentine and rosin, the most important commodities of this group, are used chiefly for purposes far removed from shipping.

NEUTRALITY. In a chemical sense, a material is neutral when it has neither an alkaline nor an acid reaction, but in the lacquer and allied industries the term is given a little broader meaning and includes all materials which have no chemical reaction with other materials used in conjunction with them. A varnish is said to be neutral when it does not react with lead or zinc pigments to produce a bodying or livering action that causes the finished product to jell or take on a semi-solid or solid state. The degree with which a varnish fails to body up with zinc or lead pigments is spoken of as its degree of neutrality. For example, a varnish that bodies only slightly is called semi-neutral, while one that goes almost to a solid state is non-neutral.

NEUTRAL OIL. A light gravity mineral oil, obtained by the distillation of petroleum oil, that is often used as a lubricant in rubbing finished work with pumice stone, rotten stone or sandpaper. Neutral oil is lighter in gravity than lubricating oil.

NEUTRAL TONER. In wood finishing technique, a stain of yellow-orange color which is used to blend colored wood streaks.

NIBS. A term used to express the presence of foreign particles which get into the lacquer or similar film while it is being applied or before it is dried. These small specks of foreign material are called nibs and often extend slightly above the surrounding surface of finishing material. Dirt nibs are usually removed by rubbing with pumice or by sanding, after the coat in

which they appear is dry and before the succeeding coat is applied. Dirt nibs in finishing material that is not sufficiently dry when rubbed or sanded often result in pullouts, which leave small holes in the surface where the dirt speck formerly was. Dirt nibs also often cause the rubbing pad to cake and form scratches and even to burn off the finish.

NIGROSINE. A blue black spirit soluble aniline dye which is fast to light and is not affected by exposure to air.

NITRATE DOPE. A cellulose nitrate lacquer solution used in coating aircraft fabric. Usually composed of the higher viscosity or "dope" type of nitrocellulose.

NITRATION. The process of chemically adding nitrogen in combination with oxygen to any material. Cellulose is nitrated to form nitrocellulose.

NITROCELLULOSE. The product obtained by subjecting cellulose to a treatment with a mixture of nitric acid and sulphuric acids, which nitrates the cotton linters. Ordinary raw cotton or the "linters" from around the seeds are most frequently used for making nitrocellulose. For different purposes the cotton is nitrated in different degrees but for use in lacquers, nitrocellulose of about 12 per cent nitrogen content has been found most adaptable.

NITRO COTTON. See *Nitrocellulose*.

NON-BLEEDING. See *Bleeding*.

NON-DRYING. A coating that doesn't dry in the course of a regular schedule. Factors such as too much oil or plasticiser or dry conditions influence this condition.

NON-DRYING OIL. Any oil which does not have the ability to take up oxygen from the air to change it from a liquid to a solid state. Mineral oils are non-drying oils as are a few vegetable oils. Most vegetable oils are drying oils or semi-drying oils.

NON-POLAR SOLVENTS. The aromatic and petroleum hydrocarbon group characterized by low dielectric constants are referred to as non-polar solvents.

NON-SHRINKING. As finishing materials dry they show some tendency to "pull down" into presented imperfections or show a wrinkle effect. Certain well balanced formulations of materials show very little or no tendency to do this, especially some of the newer types of synthetic combinations. This invisible-to-the-eye condition of shrinking is termed non-shrinking.

NON-SPOTTING LACQUERS. A clear tough lacquer having good adhesion and a retarding effect on sulphides or slag from plating solution which retards the process of spotting reaction.

NON-VOLATILE. That portion of a material which does not evaporate at ordinary temperatures is the non-volatile portion. The total of such non-volatile materials in a lacquer or similar material is called the non-volatile matter and includes the pigment, metallic drying salts, gums or resins, oils or plasticisers, and nitrocellulose. The non-volatile liquid is that portion of the

vehicle or binder which remains behind on the work after the volatile thinners have evaporated.

NUBS. One of the size gradings of various kinds of gum resins, being about the size of the end of the finger. Smaller than bold grading.

OCHRE. One of the yellow earth pigment colors found in France, Italy, England and America. A typical analysis of a good grade of ochre is: Iron oxide, 20%; Silica and silicates, 80%. The color of ochre naturally varies in accordance with the deposit from which it is obtained and the method of preparation for use in coating materials.

OFF COLOR. When the color of a finishing material does not match the standard with which it is being compared, it is said to be off color.

OFF COLOR TROUBLES. When lacquers of two different shipments or applied onto surfaces under different conditions fail to match a standard. This is the cause of great concern in lacquers and similar finishes, especially so when a freshly applied coating is compared with an aged coating.

OIL. An oil is a smooth, greasy feeling combustible material of a liquid nature, or easily made liquid by warming, soluble in ether but insoluble in water. Most oils are lighter in gravity than water and are also soluble in alcohol. Oils are classed as vegetable, animal or mineral, according to their origin, and as fixed or fatty and volatile or essential according to their behavior upon heating.

OIL ABSORPTION. The oil absorption of a pigment is its ability to absorb oil or other liquids during the grinding process. This is an important quality since the consistency, hiding power and other qualities of the finished material will be affected according to the quantity of liquid absorbed.

OIL, COLORS. Colors which have been ground to a paste or a semi-paste form in linseed or other vegetable oils. Used to a considerable extent for shading or tinting paints and enamels.

OIL LENGTH. The gallonage of oil per 100 pounds of resin in a varnish, i.e., 25 gallons long.

OIL POLISH. A finish produced on wood by successive thin coats of linseed oil accompanied by rubbing motion at the time of application. This term also refers to any polishing material containing oil as one of the essential ingredients.

OIL RESISTANCE. The ability of a finish to withstand a softening action in the presence of oils is oil resistance.

OIL RUBBING. The process of rubbing the dried film of a finishing material with oil and pumice stone or some other suitable abrasive agent. When sandpaper is used in connection with oil the operation is called oil sanding. Linseed oil thinned with naphtha or turpentine is sometimes used, as are also light gravity mineral oils, such as neutral oil, straw oil or paraffin oil. Crude petroleum oil is also used.

OIL SOLUBLE. Materials are oil soluble when they are capable of being dissolved almost completely in vegetable or mineral oils, including linseed oil,

turpentine, benzol, solvent naphtha, mineral spirits, etc. The oil soluble dyes are those which are commonly used for making concentrated oil stains by dissolving the dyes in coal tar solvents such as toluol, xylol, benzol and similar light bodied oils. These dyes are spoken of as oil red, oil blue, oil yellow, oil black, etc.

OIL STAINS. Oil stains are of two general classes; those which are made by dissolving oil soluble colors in solvent naphtha or similar solvents, usually called penetrating stains; and those which contain pigment colors mixed with a binder such as linseed oil and thinned with solvents such as turpentine or naphtha, usually called wiping stains because they are applied to the work, allowed to partially dry and then wiped off.

OILS UNDER LACQUER. Linseed oil, when used under lacquer on wood surfaces, oftentimes causes blistering. This practice should be avoided. Clear lacquer sealers or pigmented undercoaters should be used.

OLEORESIN. An oleoresin is a liquid preparation consisting of resins held in solution by volatile or fixed oils. An oleoresinous varnish is one containing gums or resins dissolved in vegetable oils and thinned with volatile oils.

ONE COAT FINISH. A finishing material involved in a single application to a finish, i.e., synthetic enamel.

ONE WAY DRUM. A light gauge steel drum used for shipping lacquers and similar products. Can be used only once for shipping those materials, that is, it goes in one direction or one way only. Also termed "one time shippers."

OPACITY. The act of covering solidly, i.e., an enamel has great opacity.

OPAL BLUE. An aniline dye used in coloring lacquers.

OPALESCENT LACQUERS. Nitrocellulose basic lacquers to which have been incorporated means of producing an opal-like sheen. Pearl essence and bronze powders figure in the reproduction of such an effect.

OPAQUE. A material is opaque when it is impervious to light or not transparent. That is, light cannot be seen through it, nor can an image be seen through it. The opacity of a material is its power of preventing the passage of light through it. See *Hiding Power*.

ORANGE MINERAL. A lead oxide pigment obtained by roasting white lead. It is lighter in color than red lead, but has the same chemical composition, Pb_3O_4 .

ORANGE PEEL. When lacquers and similar materials are applied by spraying with compressed air through a spray gun, sometimes the material does not level down to a perfectly smooth surface, but shows small raised portions somewhat similar to those seen on an orange peel. This defect, which is caused by a number of conditions, such as improper adjustment of the gun, incorrect distance from the work, insufficient reduction of the material, etc., is called orange peel, pebbling, pock marking and several similar terms.

ORANGE SHELLAC. See *Shellac*.

OVEN BAKED. Finishes that are baked in ovens.

OVER BAKED. When such materials as paint and varnish, which may require baking to a hard finish, particularly black baking japans, are baked too long

or at too high temperatures the finish may become too hard and brittle so that it cracks or chips off easily, or the lustre may be dulled. In either case, the material is said to be over baked.

OVERTONE. The top tone or color seen by reflected light which may modify the color as seen by direct inspection in diffused light. This term is also used to describe the application of a thin coat of one color over another to modify the original color.

OXIDATION. The formation of an oxide or more generally any increase in valence of an element. The act or process which oxidizes, combines or increases the proportion of oxygen. Oxygen is a gaseous element occurring in a free state in the atmosphere. An oxidizing agent therefore is a chemical substance capable of giving up oxygen to other substances having an affinity for it.

OXIDIZING. The act of forming an oxide. See *Oxidation*.

OZOKERITE. A natural hydrocarbon wax of great flexibility having a melting point of 140 to 200°F.

PADANG DAMMAR. One of the sub-grades of Batavia dammar.

PAINT. Paint is a mixture of opaque or semi-opaque pigments with liquids such as vegetable oils, varnishes, driers and thinners, or usually a mixture of two or more of these liquids, which, when spread in a thin film and exposed to the air and to light or heat, dry to a continuous protective film. Enamels are a special type of paint which is made by grinding the colors in varnishes as contrasted to vegetable oils, and usually dry out with a lustre although not necessarily so.

PAINT FARM. A segregated spot where coated panels are arranged in wooden rack arrangement and exposed to sun and weather, usually at a 45° angle facing south.

PAINT GAUGE. An instrument for measuring the thickness of a coat of paint.

PAINT METER. An instrument designed to measure light reflection and to indicate the degree by which, under the existing or natural lighting of the room, repainting will result in increased reflectivity and illumination.

PAINTING. The act of applying paint product by brushing, spraying or by any other method. Particularly painting refers to the use of paints, enamels or other colored paint materials, although in reality the term is often used more generally to include the application of any and all finishing materials as indicated by the painting of an automobile even though the finishing coats may be clear lacquer or varnish.

PAINT MILL. Any of the various types of mills on which paints, enamels and similar products are ground. Paint mills are of several varieties, such as flat mills, pebble mills, putty chasers, roller mills, colloid mills, etc. All of them are used to subdivide and incorporate the pigment particles into the vehicle or binder.

PAINT REMOVER. A strong mixture of active solvents used to remove dried paint coatings.

PALLADIUM LEAF. A new white non-tarnishing leaf with a rich depth of color and tone, for decorating and lettering of all kinds. Palladium is a noble metal of the platinum group. Usually $3\frac{3}{8}$ " square and packed in books of 25 leaves each, 20 books to the pack; also comes in rolls 67" long and any width up to $3\frac{1}{4}$ ".

PANEL EXPOSURE. Subjection of test panels to a weathering test.

PAPER MARKING. Furniture and other finished objects are often wrapped in paper for shipment. When the paper sticks to the finish in transit or leaves a mark in the finish when uncured, the finish is said to be paper marked.

PARA RED. A brilliant red, opaque, non-fading color made by the mixing of paranitranaline with beta naphthol under certain conditions. One of the strongest tinting colors known. It has one drawback in that it "bleeds," or small quantities of the color work up into coats applied over it.

PARACOUMARONE GUM. A synthetic gum resin produced by the reaction of sulphuric acid on a solution of coumarone in benzene. Coumarone is obtained from that portion of coal tar distillate that boils between 165 and 175°C. (312 to 347°F.). Paracoumarone, when properly combined with other materials, imparts acid and alkali resisting qualities to coatings.

PARAFFINE OIL. A light gravity mineral oil derived from a paraffine base petroleum oil which is used as a lubricant for rubbing or sanding the dried film of finishing materials, in conjunction with sandpaper, pumice stone, rotten stone or similar abrasives.

PASSIVE. A substance is said to be passive when it is chemically inactive.

PASTE. A stiff plastic mixture of pigment and vehicle.

PASTE FILLER. A filling material in a paste or semi-paste consistency. Iron fillers for smoothing up the surface of cast iron are usually of a paste consistency as are paste wood fillers for filling the open pores of wood before the application of clear lacquers on furniture and similar wooden objects.

PASTY. Greek, paste, barley; having the consistency or appearance of paste. The latter use is not scientific, as, for example, a pasty complexion. Applied to a rather short material. (Journal of Rheology.)

PEARL ESSENCE. A pasty consistency solution of fish scales (guanin) which is chemically treated and incorporated into an amyl acetate-nitrocellulose solution.

PEARL FINISH. A finish involving Pearl Essence, having the appearance of an iridescent pearl-like finish.

PEBBLE MILL. A paint or lacquer mill which consists of a large steel cylinder, usually lined with buhr stone, containing small stone pebbles. The material to be ground is placed in the mill with the pebbles and as the steel cylinder revolves, the pebbles fall against each other and against the lining of the mill and in this manner reduce the size of the pigment particles.

PEBBLING. When a finishing material fails to flow out to a smooth surface after being applied by spraying it, is often said to show pebbling. This is another term used interchangeably with orange peeling, pock-marking, etc.

- PEBBLY FINISH.** The result of improper atomization in the spray gun or attempting to apply too heavy a material is responsible for a condition of this character.
- PEELING.** When a finishing material loses its adhesion to the underneath surface and comes off in sizable pieces it is said to peel. Peeling is really a more aggravated form of scaling. It is often caused by moisture in the wood at the time of application of the first coat or may be due to the priming coat being of the improper type to bind to the surface being coated.
- Peeling often occurs on galvanized iron and similar metal surfaces. If the primer is of the right type, peeling on galvanized iron can be prevented by first washing the metal with vinegar; with a weak solution of hydrochloric (muriatic) acid; or with a solution of copper chloride or some similar chemical to remove the grease and slightly corrode the surface.
- PENETRATING STAIN.** Those stains which are made by dissolving oil-soluble dyes in solvents such as benzol, etc.
- PERILLA OIL.** An oil obtained from several species of "perilla"; grown in China, Japan and India. It is rarely used in the raw state but it usually is used in conjunction with other vegetable oils in the manufacture of certain types of varnishes.
- PERISHING.** The dried film of a finishing material is said to perish when it loses its life and elasticity and no longer gives a hard, tough, protective coating to the surface on which it was applied.
- PERMANENCE OF COLOR.** See *Color Stability*.
- PETROLEUM.** Another name for vaseline, which is a mixture of hydrocarbons in a soft, semi-solid form.
- PETROLEUM SPIRITS.** The fraction distilled from crude petroleum having a high boiling point—higher than naphtha, but lower than kerosene—usually made to have a boiling point and a distillation range that closely approximates turpentine. Used as a thinner in paint and varnish.
- PTHALIC ANHYDRIDE.** ($C_8H_4O_3$) A white odorless crystalline flake structure used in the manufacture of synthetic resins.
- PHENOL-ALDEHYDE RESINS.** Includes all resins produced by phenol and its homologues with formaldehyde and its homologues.
- PHENOLIC RESINS.** Includes the new "100% phenolic" resins made from diphenyl phenol or para-tertiary amyl phenol and formaldehyde, as well as the amberol types which are prepared from phenols and formaldehyde in the presence of rosin or ester gum.
- PICKING UP.** Many of the solvents used in lacquers are also solvents for the oils or gum resins used in paints or varnishes. If a lacquer containing such solvents is applied over a paint or varnish surface which contains oils or gums soluble in these solvents, it is often found that the paint or varnish film "pops up" or raises in small blisters much the same as when paint and varnish remover is applied to a varnish film. When this occurs the paint or varnish is said to "pick up" under lacquer. Picking up can be prevented by proper construction of the paint or varnish and by making certain the

film is thoroughly dry before the lacquer is applied. The term "picking up" also applies to the formation of particles of gum on the rubbing pad. See *Caking*.

PICK MARKED. A slender piece of wood with the end made tacky by partially dried varnish, chewing gum or other materials is often used, especially by the automobile finisher, for removing small pieces or specks of dirt, lint or other foreign materials from freshly coated work before the finish has set up. Such an instrument is called a pick and a finishing material which does not flow together again after lint and other defects have been removed by this method is said to be pick marked.

PIGMENT. The fine solid particles which are used in the manufacture of lacquer and similar materials. True pigments are practically insoluble in the vehicle in which they are used.

PIGMENTATION. The act of adding pigment or color matter to a vehicle of clear nature.

PIGMENT COMPATIBLE. Certain synthetic resins, due to high acidity, are not compatible with pigments. Resins that are, are known as pigment compatible.

PIGMENT STAINS. Those stains which get their color primarily from pigment; mixed with a small amount of binder and a larger quantity of volatile solvents.

PILING. During the application of finishing materials, if an excessive amount is used it is said that the material has been piled on. If the material does not level down and flow out smooth after application the defect is called piling.

PINE OIL. Formerly this term was commonly used to designate the essential oil obtained by distillation of pine cones and needles, and used in perfumery and medicinal preparations. In our industry, however, it refers to the oil obtained from stumps and other dead pine wood by the comparatively recent steam distillation and solvent process, in which steam distilled wood turpentine and wood rosin are the other major products.

PINHOLING. Pinholing is just what the name implies — the appearance on the finished surface of tiny wound holes, usually not much larger than a pin point, and generally extending down below the surface coating. Sometimes they show up in the first few coats only, but often they cannot be overcome by the number of coats, once they have made their appearance.

Both pinholing and pitting always show up while the finished surface is still soft and plastic. If the surface once becomes thoroughly dry without showing these defects, they will never appear. Shrinkage, pinholing or pitting may appear in spots or over the entire surface of a large panel. They have some causes in common, and for this reason all of them may appear on the same article, but this is unusual.

In every case where pinholing takes place, we shall find that it is caused by a gas of some sort breaking through the finished film, after it has set sufficiently to lose its flowing properties, but before it has lost its plastic nature. Pinholing is seldom found except over the pores of veneer.

Some of the causes of pinholing are moisture in the veneer, grease in the veneer, glue in the pores, dust in the pores, soft and spongy wood, poor filling and grease from heavy grades of naphtha used for reducing the filler. If for any reason the pores are not filled entirely, or if all of the volatile materials have not evaporated before finishing coats are applied, pinholing is likely to result, due either to the finishing material sinking into the unfilled pores or to the volatile material forcing its way through the film of partially set coating.

PITCH. A black or dark heavy liquid or solid substance left as a residue after distilling tar, oil and similar materials; also found naturally as asphalt. Pitches are named according to the source from which they are obtained as "bone pitch" from bone oil, "petroleum pitch" from petroleum, etc.

PITTING. Pits in finishing materials are the small round holes, somewhat larger than pinholes, that extend through one or more coats of the finishing material to form a small crater or depression. Pitting as described here does not refer to the pebbly or orange peel conditions sometimes obtained by spraying. As a rule, pitting may be traced to some foreign substance such as grease, caustic or moisture.

Grease on the surface being coated might cause pitting. Greasy benzine used in thinning the paste wood filler or other finishing materials is another cause. Baked japan work shows pitting when there is caustic or grease on the steel, also when there is moisture in the japan. Any non-drying oil, grease, water, caustic or similar materials that might get on the work or in the finishing material itself will probably cause pitting. Sprayed work shows pitting more frequently than brushed work, usually due to oil or moisture getting into the material through the air line.

A careful examination of the defective work after drying often indicates whether the trouble is caused by moisture or oil. If the rings seem to have a small speck in the center it is a sign of oil and this can be verified by rubbing down on the work. If the rubbing shows the finishing material to be soft around the rings and imperfectly dried, it shows that oil was the cause of the trouble. When pitting is caused by moisture, little effect is had on drying. When pitting is due to moisture in the finishing material it can usually be put into good condition again by heating until the traces of moisture are driven out.

PLASTER OF PARIS. Made by partially dehydrating gypsum or a natural hydrate form of calcium sulphate. When mixed with water it sets and forms a hard mass.

PLASTIC RESIN. Synthetic resins which are of a plastic like nature.

PLASTICISER. Usually high boiling solvents added to lacquers to increase the elasticity and flexibility of the dried film. Also sometimes spoken of as "softeners."

A substance which lowers the consistency of a mixture. Some substances are of too high a consistency to act as colloidal solvents even though they are also to disperse the colloids. Thus camphor converts nitrocellulose into a

plastic mass rather than a colloidal solution. It is therefore known as a plasticiser. (Journal of Rheology.)

PLASTICITY. The susceptibility to and the retention of deformation. Plasticity is that property which enables a material to be permanently deformed without rupture under the application of pressure, provided that the ratio of flow to force is variable.

Note: A solid is a plastic when it can be readily molded into a desired form to cause flow. The shearing stress must exceed the yield value. Liquids do not exhibit plasticity because they do not retain their shape and therefore cannot be molded advantageously. Plasticity may not be defined quantitatively because it is a complex property made up of yield value and mobility or their equivalent. (Journal of Rheology.)

PLIABLE. Flexible.

POCK MARKING. When finishing materials are applied by spraying, the surface sometimes does not level down smooth and results in a pebbly construction somewhat resembling that on the peeling of an orange. This is called pock marking, pebbling and/or orange peeling. These defects are caused either by improper application or by the fact that the material is not properly constructed for application by spraying. It is usually possible, however, to spray most any material satisfactorily provided the proper adjustment of nozzle and pressure and the correct amount of the proper reducer is used.

The most frequent cause of pebbling is either too high or too low air pressure for the size of the nozzle and the body or viscosity of the finishing material. If the pressure is too low, the material is not properly atomized and goes onto the work in "chunks" which do not level out properly before the coating sets. If the pressure is too high, too much of the volatile thinners are evaporated so that the material strikes the work in a partially dried state and does not level down properly. By properly adjusting the pressure most pebbling can be overcome.

Another cause is the holding of the gun too close or too far from the work. This acts in much the same way as if the pressure were not right. If the gun is too close, the material is not properly atomized; if it is too far away, so much of the thinner is evaporated that the ability to flow or level out is lost. This fault is often found where operators are on a piece work basis and are in a hurry to coat the article as quickly as possible.

The spraying of warm finishing materials onto cold surfaces could also cause pebbling or pock marking, as could the use of air that is sufficiently colder than the finishing material to chill it and prevent it from leveling out properly.

Lacquers which set up relatively quickly after being sprayed give the greatest trouble from pebbling. If after all other factors have been checked and regulated, pebbling still persists, it may be that the coating itself contains thinners which evaporate too quickly.

The remedies for pebbling or pock marking are to adjust the pressure; the size of the nozzle; the distance of the gun from the work; the body of the

coating and the temperature of the air, the coating materials and the work so they harmonize with one another. If attention to these details does not remedy the effect, it is well to put the question of getting the proper kind of material for spraying to the old established manufacturers who have made a study of the subject and offer finishing materials that are especially adapted for spraying.

POLARISCOPE. An instrument for exhibiting polarized light.

POLAR SOLVENTS. Such solvents as alcohols and ketones that contain hydroxyl or carbonyl groups, have high dielectric constants and show strong polarity.

POLISHES. Liquid or paste materials of various compositions used for producing a high lustre on finishing materials.

POLISHING. The act of increasing the lustre of the dried film of a finishing material by mild friction. Certain piano finishes are often polished with the palm of the hand. Furniture and other similar objects are usually polished by the aid of a prepared polish applied with a soft cloth. Lacquers are sometimes polished by means of a mechanical buffing wheel.

POLYCHROME. When a number of colors are blended together in producing a finish, this is known as polychroming. Used principally on picture frames, furniture, etc.

POLYMERIZATION. When the molecular weight and properties of a substance change without changing the chemical composition the material is said to polymerize. An example is the gelatinization of tung oil when heated.

PONTIANAK. A dark fossilized gum resin obtained from New Caledonia and used in the manufacture of varnishes and similar products. True pontianak is a hard gum resin and should not be confused with the softer East India gum resins which are also known by some as pontianak.

POPPY SEED OIL. A pale golden yellow drying oil obtained by expressing the seed of the poppy.

POROUS. When a finishing material does not dry with a hard, dense film, free from holes and small voids, it is said to be porous. Porous undercoats absorb moisture from the rubbing operation and cause difficulty from peeling, checking, cracking, etc. Porous undercoats also allow the next coat of material to sink in to a certain extent, giving a deadened effect.

POTASSIUM FERROCYANIDE. Here commonly known as yellow prussiate of potash. When mixed with ferrous sulphate under proper conditions (providing for oxidation of the ferrous sulphate to the ferric state), ferric ferrocyanide (Prussian Blue) is formed. See *Prussian Blue*.

POUNDING. When a dry pigment is enclosed in a cloth bag and applied to a surface by striking a bag against it, this is known as pounding.

POWDERING. When a finishing material is so short or brittle that its dried film shows the formation of powder when the finger is rubbed over the surface rather rapidly and in succession so as to cause friction, it is said to powder. The appearance of any powdery substance upon a dried film from any cause whatsoever, is called powdering. See *Flowering*.

POWDER STAINS. Dry coloring matter which gives coloring to stains used in staining woods.

PRECIPITATE. A substance separated from a solution in solid form by application of cold or heat or by a chemical reaction.

PRESSING. Just another term for "printing" or "marking" of the finish by pressure.

PRESSURE FEED. A metal container in which spraying lacquers are placed and forced through feed hosing to the gun by compressed air.

PRIMARY COLOR. A primary color is one in which no trace of another hue or color is discernible and furthermore it is a color which cannot be produced by mixing any other two colors. The three true primary colors are red, yellow and blue. From the standpoint of paint making black and white may also be considered as primary colors, since they cannot be made by mixtures of any other colors. Technically, however, black is the absence of all color and white is the presence of all colors.

PRIME COAT. Referred to as that application as applied direct to the metal and sandwiched between it and the finishing coats.

PRIMER. That coat of finishing material which is applied first or directly next to the uncoated surface is known as a primer or first coater. Primers may consist of paint varnish or lacquer materials. In other words, it may be color varnish or a varnish to which a small amount of transparent, inert pigment has been added to form what is known as pigment first coater, or it may be a paint material containing enough pigment to cover solidly or it may be a lacquer product either clear or colored. Different types of primers are used for different purposes; since it is the foundation coat which binds succeeding coats to the unfinished surface it may be so constructed as to adhere tenaciously to the surface, must dry hard, must be tough and elastic enough to withstand expansion and contraction through temperature changes without cracking, and must in addition possess any additional qualities that may be required for the particular work in hand.

PRINTING. When pressure is applied to a finished article by sitting on it or by reason of the method of packing, the finish may show a "print" of the material directly in contact with it. Varnish is also said to print when hot dishes or such articles mar the surface and leave a mark.

It is said to be very difficult to make a varnish that will be absolutely non-printing, but by the use of proper materials and methods during the manufacture and by the use of proper schedules in the furniture factory during the application of the varnish to the work, a varnish can be made that is very resistant to printing. Due to the high grade of raw materials and the costly methods of manufacture such a varnish is naturally higher in price than those not required to stand this severe test.

A number of things outside of the varnish have an influence upon the ease with which a finished surface can be imprinted. If sufficient time is not given for the stain, filler and undercoats of varnish to dry, the foundation upon which the finish is built will be soft and printing is likely to result when the finished product is subjected to pressure; likewise if the varnish is applied

too heavily, it will not dry through as thoroughly as it should and it will be more likely to print. It is evident that the longer the time allowed between coats, the longer the time after the finishing before applying pressure, the harder will be the varnish and the less likely it will print.

Any varnish finish of any character has a tendency to show softening when subjected to high temperatures such as frequently prevail in box cars during the summer time or in some storage plants. The extent to which this softening will be noticed will be measured by the degree of heat and the length of time the finished object is exposed to these conditions provided, of course, that the varnish is exactly the same in every case. The colder the temperature the less likely it will be to print, but care must be taken not to go too far in this direction or there will be danger of cracking and checking.

Paraffine or oil paper should not be used for packing varnished furniture because the paraffine oil in these papers has a tendency to soften the varnish, especially if there is any heat present, and the result will be that more printing will take place than if the papers were not used. Experience has shown that an ordinary hard glazed paper gives much better results than treated papers of the above mentioned type. If the wax paper is used, it is best to get one impregnated with a wax that has a high melting point, but it is not recommended under any circumstances where it is possible to use thin, hard glazed wrapping paper similar to that used in retail stores.

Care should be taken to construct the packing case for a given piece of furniture so that the pressure necessary to hold the article firmly in place will be brought to bear on an unexposed part where any printing that may result from it will not mar the beauty of the finish. In these cases where it is not possible to pack the object without exerting some pressure to the exposed surface, care should be taken to apply no more pressure than is necessary. Every piece of furniture, of course, will have to be treated differently and the packer must use his own judgment as to the best method to use.

PROOF SPIRIT. A mixture of equal parts of water and grain alcohol is said to be 100 proof and it contains 50 per cent alcohol by volume. Higher proportions of alcohol are expressed as spirit proof by doubling the difference above 50 per cent alcoholic content and adding this to the figure 100. As an example: If the mixture contains 60 per cent of alcohol by volume the mixture is 120 proof. ($60 - 50 = 10$; $10 \times 2 = 20$; $20 + 100 = 120$ proof.) Similarly, 188 proof alcohol contains 94 per cent alcohol. $188 - 100 = 88$; $88 \div 2 = 44$; $50 + 44 = 94$ per cent.

PROPYLENE OXIDE. ($\text{CH}_3\text{CHCH}_2\text{O}$) A colorless liquid used as a nitrocellulose, cellulose acetate and resin solvent.

PRUSSIAN BLUE. A blue pigment made by the action of potassium chlorate and sulphuric acid upon a mixture of yellow prussiate of potash (potassium ferrocyanide) and copperas (ferrous sulphate). The technical name for Prussian Blue is ferric ferrocyanide, $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$. Prussian Blue is also known as Chinese Blue, and by other names, depending upon the exact shade. Prussian Blues have a characteristic greenish blue cast. They are deep in color and have great strength, they are easily affected by alkali, but not

by acid. Fairly non-fading, except when used in very small amounts by tinting.

PRUSSATE OF POTASH. The common name for potassium ferrocyanide, one of the materials used in the manufacture of Prussian Blue.

PUCKERING. When a finishing material crinkles or shrivels to a wrinkled surface upon drying it is sometimes referred to as being puckered. See *Crinkling* and *Wrinkling*.

PUDDING. A finishing material puddings up when it jells or livers and has the appearance of pudding.

PULLING OUT. When small spots of finishing material are apparently pulled out during the rubbing operation, this condition is described as "picking up" or "pulling out." See *Caking*.

PULLING UNDER THE BRUSH. When insufficient material is used in the brush or when the material is too heavy or too quick drying there is sometimes a decided pull as the material is applied to the work or as the brush is passed through the finishing material. This can be overcome by further reducing the material being brushed or by other corrective measures suggested by the above description of the trouble.

PULVERULENT. Consisting of, or reducible to, fine powder.

PUMICE STONE. The best pumice to use for either coarse or fine rubbing is pure Italian pumice, imported in the rock form and ground in this country. Pumice is of marine volcanic origin, being a solidification of the spume formed by the escaping steam of the surface of molten lava as discharged from submerged volcanoes. This liquid rock was so rapidly cooled and agitated that the whole mass swelled into a froth which at once hardened into the very porous stone known as rock pumice. The Island of Lipari, Italy, is reported to have the finest deposits and from this source the rock is imported and ground in modern crushing machinery after which it is sorted into the various grades according to the size of particles.

The grades are known as 4-F, 2-F, F, 0, 0-½, 1, 1½, 2, 3, 4, 5, 6 and 7, the 4-F being the finest and 7 the largest. The first six gradings are the ones used in finishing work. Ground pumice of domestic origin is on the market, but the Italian is considered best for high grade work because it works up better than the others, leaving the surface with fewer scratches and as a consequence it is much cheaper to use than domestic or ground clay, although somewhat more expensive in first cost.

PUTTY. A stiff, pasty material consisting of pigment and binder, used for filling up imperfections in wood or metal surfaces. Also used for setting window panes. See *Glazing Putty*.

PUTTY COAT. A heavy plaster-like mixture applied with knife and used to fill surface impressions before proceeding with finishing coats.

PUTTY KNIFE. A knife used for applying putty. Several widths of putty knives with various degrees of stiffness in the blades should be provided for applying glazing putty or hard putty according to the work in hand.

PYROXYLIN. See *Nitrocellulose*.

RAIN SPOTTING. Rain spots are usually caused by drops of water which contain small amounts of mineral substances evaporating on a surface of finishing material and thus depositing the small traces of minerals in the film of the material. Occurs quite frequently near the ocean, in an alkali country or in a large industrial district where large quantities of smoke containing sulphuric acid and other chemicals are in the air.

Rain spotting or water spotting most often takes place on blues and other more or less transparent colors. Sometimes exposure to the sunlight will remove the spots; at other times they may be removed by washing and polishing with a good grade of polish; but under certain conditions, it is almost impossible to remove such spots with any treatment other than refinishing.

RAISING OF THE GRAIN. See *Grain Raising*.

RAISIN SEED OIL. A golden yellow oil of fatty odor and a nutlike taste. Procured from raisins. Sometimes used as a substitute for linseed oil in paint products.

RAT TAILING. This term was often used in the days when finishing varnishes were most commonly used on carriages or automobiles, to define a defect in the finish which very much resembled a rat tail and which was usually caused by a bubble or a speck of dirt flowing down a short way, leaving a thinner streak of varnish behind, which failed to be filled up with new varnish before it set so much as to lose its flowing power.

RAW SIENNA. One of the brown earth pigments found in France, Italy, England and America. It contains from 60 to 70 per cent hydrated ferric oxide, the rest being alumina and silica. The color naturally varies according to the exact chemical composition, the deposit from which it is secured and the method of preparation.

RAW UMBER. One of the brown earth pigments, consisting essentially of hydrated ferric oxide but differing from raw sienna in containing, in addition to alumina and silica, 10 per cent or more manganese dioxide. The color varies according to the locality from which it is obtained and the method of preparation. Umber is obtained from deposits in Italy, France and England and also from the Island of Cyprus.

RECOALESCENCE. The union of emulsion globules, resulting in a "breaking" or separation of the emulsion.

RED LEAD. (Pb_3O_4) One of the red pigments used to a considerable extent for priming structural steel and similar metallic surfaces. Red lead consists of about 90 per cent true red lead or plumbic oxide and about 5 or 10 per cent litharge.

RED OXIDE. See *Iron Oxide*.

RED TONER. A shorter name for the pigment known as paranitranaline red.

REDUCE. To reduce a finishing material is to thin its viscosity or consistency by the addition of volatile materials, usually of a lighter gravity than the material being used. When a volume of reducer equal to 25 per cent of the material being reduced is added, the material is said to be reduced 25 per cent, or one part of reducer has been added to four parts of the material.

Similarly, 10 per cent reduction is one part of reducer to ten parts of material, and 100 per cent reduction is equal parts of material and reducer.

REDUCER. The volatile constituents used to thin the viscosity or body of a finishing material to such an extent that it may be easily applied, or for some similar purpose. Also see *Thinner*.

REFRACTIVE INDEX. A measure of the deviation from normal that a beam of light undergoes upon passing through a given substance.

REFRACTOMETER. An instrument for determining the refractive index of a material.

REINFORCING AGENT. An essential factor in increasing the hiding power of opaque (high refractive index) pigments has been the decrease in particle size, which has tended to weaken the paint film. Accordingly, the admixture of colorless and transparent pigment particles of larger size is recommended as a means of reinforcing or strengthening the film. A pigment used for this purpose is called a reinforcing agent.

RELATIVE HUMIDITY. An expression in terms of percentage of the amount of water vapor in a given volume of air at a given temperature as compared to the total amount of water vapor the air could hold at that temperature.

In other words, it is the percentage of saturation of air with water vapor at a given temperature. If a given volume of air contains only half as much water vapor as it could hold at that temperature it is said to be 50 per cent saturated or to have a relative humidity of 50 per cent.

RESIN. A solid or semi-solid organic substance, chiefly vegetable, which is soluble in ether, alcohol or in similar solvents, but not in water. In our industry, the term "resin" is commonly used to designate the resinous materials or so-called gums used in the manufacture of finishing materials.

RESINATE. A metallic soap in which the organic acid constituent is obtained from rosin. See *Metallic Soap*.

RESIN HARDNESS. Means of evaluating brittleness or softness of gum resins; e.g., 1 (brittle), 6 (soft).

RETARDERS. Combinations of liquid solvents and extenders which are added to a given lacquer as a means of slowing the evaporation by retarding it. Retarders are usually composed of the higher boiling and slower evaporating solvents.

REZYLs. Synthetic resins of the alkyd type, made from phthalic anhydride.

RHE. The unit of measurement of fluidity.

RHODULINE HELIOTROPE. Aniline dye used in colored lacquers. Soluble in lacquer solvents, fast to light, and is not affected by exposure to air.

RIBS. Raised ridges in the finish caused by heavy brush marks which were not sanded or rubbed from underneath coats before finishing coats were applied.

RIGIDITY. (Latin, rigidus) The property of bodies by which they resist an instantaneous change of shape. The reciprocal of elasticity. In physics a rigid body is assumed to be not only rigid but stiff as well.

Quantitative: (Greek, elauno, drive) The rigidity is measured by the shearing stress required to displace elastically either of two parallel planes one

centimeter apart to the extent of one centimeter, the space between the planes being filled with the elastic material. (Journal of Rheology.)

RESINIFY. The process of condensation to force polymerization of a resin solution (heated.)

ROLLER COATING. The application of a finishing material by means of a series of hard rubber and steel rollers. The surface on to which the material is transferred by rolling is passed between the rolls.

ROLLER MILL. A paint mill which depends upon two or more heavy steel rollers set quite closely together and revolving in opposite directions, to grind the pigment into the liquid.

ROPEY. When a paint or varnish material does not flow out and level down after being applied with a brush, leaving heavy brush marks and acting much as though it has a false body due to a livering action between the liquids and the other ingredients, it is said to be ropery.

ROSAZEINE. Aniline dye used in colored lacquers. Soluble in lacquer solvents, fast to light, and is not affected by exposure to air.

ROSIN. The molten resin which remains in the still after the distillation of gum spirits of turpentine from the gum turpentine obtained by wounding living pine trees is strained into barrels and solidifies, becoming the (gum) rosin of commerce, which is graded according to its color. When used as a varnish raw material, rosin is generally, but not always, hardened by the addition of lime, resinsates of the heavy materials such as zinc, zinc oxide, calcium oxide and similar substances, or by prolonged heating. Rosin is also known as "colophony." Also see *Wood Rosin*.

ROSIN ESTER. The product formed by heating rosin and glycerine with or without catalysts until the alcohol groups of the glycerine have neutralized most of the abietic acid in the rosin. See *Ester Gums*.

ROSIN OIL. Obtained by the fractional distillation of rosin and consisting of that portion which comes off above 360°C.

ROTTENSTONE. Rottenstone, known also as tripoli, is a siliceous limestone which has undergone a continual bleaching process in nature and is of different character and softness than pumice. This important adjunct to coating material polishing is manufactured by carefully grinding and bolting the lump stone, also known as "rubble," to a uniform fine powder. It is said that the rottenstone of domestic origin and also that obtained from Holland is obtained from slate deposits and is not suitable for polishing.

The lump stone most desirable for polishing on account of its softness is imported from England or Belgium and ground and graded in this country. This is offered to the trade by the importers and grinders in the powdered form in several grades and in the brick form, which is the manner in which it is most largely used. The bricks are made from the finely graded powder mixed with water and a suitable binder. The lump rubble, when broken up, frequently gives off a fetid odor from which no doubt it obtained the name rottenstone.

ROUGH STUFF. A surfacing material used in automobile painting and for similar purposes. It is a heavy pastelike material prepared from white lead,

keystone filler and other pigments in conjunction with proper varnishes, oils and driers. It is usually reduced with turpentine or naphtha to a brushing or spraying consistency for application. It fills the imperfections in the metal and dries rock hard within a few hours. One or not more than two coats are applied daily and from two to five coats are used. It is usually rubbed with a rubbing stone and water or sometimes it is sanded with water and waterproof sandpaper. It is not so frequently used today as formerly because it is harder to sand or rub than sanding surfacer.

RUBBER FINISH. A black finish having approximately the lustre of hard rubber.

RUBBING. The act of applying mechanical friction, usually in conjunction with an abrasive, to the dried film of a finishing material to bring it to a plane surface to deaden the lustre, to remove specks of dirt or for a similar purpose. Water and pumice stone, oil and pumice stone, oil and sandpaper, water and a rubbing brick and similar materials are used for rubbing. A water rub is one in which water is used as the lubricant and an oil rub is one in which oil is used. Burlap, woven felt, and similar materials are used for the rubbing pad by means of which the abrasive is rubbed over the surface to be cut down.

RUBBING BLOCK. A block of felt on wood or similar materials used for rubbing.

RUBBING BRICK. A brick of smooth texture, finely divided abrasive material which has been pressed into brick form, used with water for rubbing or surfacing down surfacer coats on automobiles and similar objects.

RUBBING COMPOUND. An abrasive mixture used to "cut" the uneven surface of a coating.

RUBBING FELT. A block of felt used for rubbing finishes with pumice stone or other abrasives.

RUBBING OIL. A neutral, medium heavy, mineral oil used with pumice stone or with sandpaper for oil rubbing the dried film of a finishing material. Neutral oil or paraffine oil is often used for this purpose.

RUBBING STONE. Somewhat similar to a rubbing brick except that a rubbing stone is usually a natural product just as it has been mined from the quarry and has not been pulverized and again pressed into brick form.

There are several makes of rubbing stone on the market, and they are graded into soft, medium and hard. The best brick for all around work is a medium one. It is said that one of the best types of rubbing stone is a native product mined from stone quarries in Indiana, in that it cuts faster, leaves a smoother surface and does not clog or scratch.

The stone is usually in the form of a brick about four inches long, two inches wide and an inch and a half thick. The brick itself is too rigid and inflexible for good work and most automobile painters cut it up in pieces about three-quarters of an inch on each side and make what is called a "gang" which is flexible and which allows the slush to be worked into the cracks.

RUBBING THROUGH. When in the course of rubbing surfaces, as lacquer coatings, the undercoating shows through.

RUNS. Defects in a finish caused by an excess of finishing material being applied which did not "stay put" but flowed down in a curtailed or ragged effect. See *Sags*.

RUSTING. The gradual loss of lustre with the apparent formation of a film of yellowish or discolored material over the surface of the finished article is called rusting. Rusting also refers to the formation of a corrosive metal. See *Corrosion*.

SAGS. Irregularities of surface due to uneven flow. In dipping materials, bubbles sometimes get on the work and when they break, sags or runs are left on the surface. Sags are also caused by the collection of quantities of material in cracks, crevices, corners and holes, which allow the finishing material directly next to them to continue to flow longer than the surrounding surfaces. Whenever an excess of material is applied by any method on horizontal or upright work, sags are likely to form.

SALOL. (Wood Phenyl Ester.) A colorless crystalline powder which, when pure, is without odor. Used for colorless and odorless plastics. An odorless camphor substitute which is superior to camphor for certain purposes, i.e., waterproofing cosmetic boxes, fruit flavors, etc.

SALT SPRAY TESTING DEVICE. A machine device used on metal coated panels for testing finishes, which indicates pitting and lasting qualities of coated surfaces as exposed to salt water spray.

SANDARAC. A hard but brittle gum resin which comes from Africa. It has a faint odor resembling that of turpentine and a slightly sharp balsamic taste.

SANDING IN THE WHITE. A sanding operation of furniture before the filler or coating operation.

SANDING SEALER. Generally referred to as a type of lacquer which acts as a seal coating over applied wood filler and under finishing lacquers. This lacquer is dry sanded to smoothness. Also applied under clear varnish coatings.

SANDING SURFACER. A heavy consistency finishing material used for building the surface in automobile painting and for similar purposes. While sanding surfaces were formerly made only of paint materials, today we also have lacquer surfacing materials.

Sanding surfacer is very much like rough stuff in appearance, but it is so manufactured that it sands easier. To get this quality the proportion of oil is decreased slightly and fluffier pigments such as talc, are incorporated. Formerly sanding surfacers had to be sanded dry without the use of water or oil, but today there are sanding surfacers to be had which absorb water so little that they may be sanded safely with waterproof sandpaper and water.

SANDOMETER. A machine device which drops grains of sand onto a freshly coated panel as an indication of speed of the drying of the film.

SANDPAPER. A paper coated with an abrasive material which is used for sanding wood, metal or finishing materials to a surface. There are three main types of sandpaper according to the kind of grit used. First there is

the so-called emery paper or emery cloth which is coated with very hard sharp crystals of emery and is used for sanding down the metal preparatory to priming. In recent years artificial grit of a very hard, sharp nature is replacing emery to a considerable extent for this purpose. Grade $\frac{1}{2}$ paper should be used for this purpose.

Then there is the garnet paper in various degrees of coarseness which is used for sanding wood and for dry sanding various coats. The third type of paper is the waterproof paper which is usually coated with still a different type of artificial grit than that used to replace emery. This paper is extensively used with water or with oil for sanding various coats including the surfacer coats, and finish lacquer coats.

The type of grit of the paper should be chosen carefully to fit the work at hand. Rubbing stone and lump pumice were formerly used quite extensively for surfacing down rough stuff and other surfacer coats, but they are being rapidly replaced by the newer waterproof sandpaper which cuts quite as rapidly but is less likely to leave an absolutely plain surface in the hands of a novice.

SANDY. A finishing material is said to be sandy when it dries with a gritty or dirty surface due to unground pigment particles, dirt or similar causes.

SANCTICIZER. A solvent plasticiser used in nitrate and acetate lacquers.

SAPONIFICATION NUMBER. The number of milligrams of potassium hydroxide required to neutralize all the acid in one gram of resin, etc.

SARDINE OIL. Obtained by boiling and pressing the sardines after they have been cut up into fine pieces.

SATIN FINISH. When a dried film of lacquer or similar materials does not have a full lustre, but one resembling the lustre of satin, it is said to have a satin finish. See *Flat Lacquers*.

SCALING. This is flaking in an aggravated form, in which large pieces of the dried finishing material come off, exposing the bare surface below.

The term "scaling" also describes the cobwebby appearance of a varnish when the top coat has been rubbed through in places, showing the next coat underneath. Scaling does not prove to be a detriment where a flowing coat is applied after the coarse rubbing, provided the undercoats are dry enough to prevent heaving or kicking up, because this coat is applied on a level surface and is not likely to be rubbed through during the fine rubbing process. When a coat of varnish is not used after the coarse rubbing, scaling is a very undesirable feature.

In its final analysis scaling of rubbed varnish is caused by an uneven surface — caused by uneven wood surfaces or otherwise — which allows some parts of the varnish to be rubbed more than others. If the top coat of varnish were not rubbed through, there would be no scaling. But if the varnish film has been built up properly there should be no scaling, even though the top coat is rubbed through in places. It is because the coats are improperly knitted together that the edges of the rubbed-through spot become visible. Further rubbing causes the edges of the broken spot to roll back and forms this scale. If one coat of varnish is allowed to become too dry and hard before the

next one is applied, scaling is likely to result because the two coats do not properly knit to each other. Where varnish is piled on too heavily and it top dries, the rubbing operation is likely to cause the varnish to sweat and scale. If each coat is dried properly there is not likely to be any scaling. Some varnishes do not have good solvent properties and for this reason, the various coats are not likely to knit to each other as well as they should.

The use of entirely different varnish coats, one over the other, is likely to cause scaling.

SCARLET LAKE. A pigment made by the precipitation of an aniline color upon a base of barium sulphate and alumina hydrate. Also sometimes precipitated on a base of orange mineral or red lead. One of the commercial scarlet lakes has approximately the following composition: Precipitated aniline coloring matter, 33 per cent; barium sulphate, 42 per cent; alumina hydrate, 25 per cent.

SCHEDULE. The sequence and types of finishing materials when given with methods of application, drying times and temperatures, rubbing operations, etc., form the schedule of finishing on a given piece of work.

SCRAPER. A broad-bladed knife used for aiding the removal of old lacquer, paint or varnish coats.

SCRATCHES. Scratches are left in work when it is rubbed with too coarse an abrasive or without sufficient lubrication or with too much pressure.

SCREEN TEST. A screen test is frequently made of dry pigments to determine the fineness of the particles of pigment. Usually determined by washing a weighed sample of the pigment through a fine mesh screen and weighing the residue which does not pass through the screen.

SEALER. A sealer is a finishing material which is applied over another coat of finishing material or over the bare, uncoated surface to seal the pores and stop suction of succeeding coats into soft or porous spots. It is usually a clear liquid, although sometimes contains inert pigment matter and sometimes colors. It dries to a hard, dense, non-porous surface. Also see *Sanding Sealer*.

SEBACIC ACID. Odorless light colored crystals used in the manufacture of synthetic resins and solvents.

SEEDINESS. Seediness in lacquer and similar finishing materials appears in the form of small grains resembling undissolved gum which is often caused by a sort of break or settling out of some of the gum resin content of the finishing material. When a seedy material is applied to glass, it shows up with a very fine and specky surface. One cause of such separation may be the severe chilling of certain types of finishing materials while in transit or during storage. Also caused by the addition of thinners which are not good solvents for the resin and/or other solids in the material.

SEMI-DRYING OILS. Those oils which are only partially hardened or are changed into a sticky mass upon being exposed to air and sunlight. The chief semi-drying oils used in paint, varnish and lacquer are soybean oil, corn oil and cottonseed oil.

SEMI-FLAT LACQUER. A lacquer having the appearance of having been frictionally rubbed. Usually arrived at through the introduction of a pigment (inert) . A type of satin finish.

SEMI-GLOSS. A material is said to have a semi-gloss lustre when it dries out to a sheen about half way between full gloss and a dead flat finish.

SEMI-TRANSPARENT. Not opaque. When a pigmented lacquer has been reduced with thinner and flowed onto a glass surface, the material is said to be semi-transparent, showing, as it does, light through the film.

SEPARATION. A term used to express what happens when two or more liquids are put together and shortly thereafter they do not "stay put," but show a complete separation. Also this term is used to describe the breaking up into one or more of the integral parts in any finishing material, as for example, the gum portion or nitrocellulose portion of a lacquer may be separated from a lacquer by the introduction of the wrong type of solvent, i.e., gasoline or water.

SETTING UP. The initial drying of a lacquer film to a point where it has lost its ability to flow is known as setting up. In other words, it is the drying which takes place, due to the evaporation of the volatiles present.

SHADE. The degree of a color is called its shade, as, a dark shade of green which is a green color of a lower luminosity. The word shade is also used as a verb to denote the act of changing the color by additions of small quantities of other colors, as when shading a batch of lacquer to a standard.

SHARP DRYER. A finishing material is said to be a sharp dryer when it quickly dries completely and thoroughly all the way through the film without any mushy effect.

SHARP LUSTRE. A finishing material is said to have a sharp lustre when it dries to a very high gloss.

SHEARY. A material is sheary when it is not uniform in gloss after being applied and dried.

SHEEN. The degree of lustre of the dried film of a finishing material. A high sheen means that the material has a high gloss. Usually used to describe rubbed surfaces or the lustre of flat drying materials.

SHELLAC. The commercial form of "lac," a modern gum resin, produced by the action of an insect on the twigs of certain trees which grow in India and nearby places. Shellac is commonly known as "seed lac," "hank shellac," "orange shellac," "white or bleached shellac," "refined shellac" and a variety of other names, depending upon the degree of purity and the treatment which it has undergone.

The twigs which are encrusted with the secretion of the lac insect that produces shellac are known as stick lac. These twigs are broken from the trees and cut into short lengths by the natives, dried in the sun and packed into bags for shipment to shellac manufacturers. The sticks are then ground and sifted to separate the lac from the wood and dirt.

After stick lac has been ground and the lac sifted from the wood and dirt, the finely divided lac is washed and pressed still finer in shallow tubs of

water to form the finely pulverized shellac, known as seed lac. This is the form of shellac produced by the natives through the process of melting the seed lac and sticking the soft shellac into thin sheets, which are hardened and then broken up into small pieces, known as shell lac or piece lac.

After the thin sheets of melted lac produced by the natives are hung up until hard and dry they are broken into smaller pieces which somewhat resemble a shell in appearance. This form of lac is the most commonly used in making spirit varnishes and it is from this form that the commercial gum derives its name of shellac. Since the color of this shellac varies from a reddish brown to orange the commercial form of the material is known as orange shellac. White or bleached shellac is made by bleaching the orange shellac with such agents as chloride of lime. Refined shellac is shellac from which the small percentage of natural wax has been removed. Shellac is used as a finishing material itself when dissolved in alcohol and is also used to some extent in other surface coatings.

SHELLAC SUBSTITUTE. A spirit varnish made by dissolving various gums in denatured alcohol, benzol or other solvents with the intent of producing a product that has characteristics similar to those of a pure shellac varnish. Manila and other gums are often used for this purpose, but it is doubtful if there ever has been a substitute shellac that is equal to pure shellac for finishing purposes. The main appeal of a substitute shellac is its lower cost.

SHELLAC VARNISH. A varnish made by "cutting" shellac with denatured alcohol. Shellac varnishes produce a pleasing finish without much lustre, but a shellac finish, unless very carefully applied and dried, is easily injured by scratching and turns white permanently from contact with water.

SHINE. A finishing material has a shine to it when the dried film has a very high gloss.

SHORT. Lacking toughness or elasticity due to small amounts of plasticiser or to similar causes. A dried film of finishing material is referred to as being short when it is quite brittle. The undried material is said to be short when it is crumbly and has no flowing properties.

SHORTNESS. The opposite of length—shortness is a quality possessed by a solid which has a high yield value and high mobility, non-ductile; for example, butter. A short solid "necks down" rapidly and shows little tendency to be drawn out into threads. Emulsions are all short. (*Journal of Rheology*.)

SHRINKAGE. Shrinkage, as the word is commonly used, when speaking of finishing materials, is the term applied to the disruption of the level plane of finished surfaces, resulting in a loss of lustre, sometimes after the finished article has stood for a number of months. This is true only if the finish has been left in the gloss, or has been dull rubbed and then polished back to a gloss. If it is left in the dull rubbed condition, the finish may "die away" until there is apparently less depth or fullness in the finish, although the finished film may be as thick as ever. Both of these conditions are the result of similar causes, and the terms are often used interchangeably.

There is always more or less shrinkage in finished articles, although with

proper care, during the manufacture and finishing of the article and during its subsequent use, years are sometimes required for this condition to show up with enough prominence to be noticeable.

As a general statement, it can be said that shrinkage is caused by a movement, although it may be ever so slight, of the wood, or the underneath coats of finishing material after they have "set" or have become partially or completely dry. If the movement is sufficiently severe, or if the finish is not elastic enough to come and go without expansion or contraction, there will probably be signs of "cracking" or "checking." Shrinkage takes place more frequently and in a shorter time on veneered work than on a solid wood. As a general rule, it will be more serious on mahogany veneer than on walnut or oak veneer, due to the fact that mahogany is softer and liable to be more spongy, although if the conditions are right, it may show up as badly on these plywoods as on any other.

Some of the more common causes of shrinkage on veneered work are described below: If the veneer contains an excess of moisture, which was absorbed from the glue or from some other source, it is likely to dry out after the article has been finished. When moist wood dries out, it shrinks more across the grain than it does in length. For this reason, it sometimes happens that cross-banding, especially if it contains more moisture than the veneer at the time of gluing, shrinks more than the face veneer, causing it to crumble up after the finishing materials have been applied. This caused the finish to shrink and lose its lustre.

Since the shrinkage of lacquer or varnish is caused by a slight movement of the veneer or undercoats of finishing material, an expansion of the veneer, due to the absorption of moisture, is just as likely to cause loss of lustre as a contraction due to loss of moisture. Consequently if the veneer is too thoroughly dried at the time of finishing, shrinkage is likely to result. The presence of alkali or other impurities in the glue used for laying the veneers, may effect the finish and cause shrinkage. Dust in the pores of the wood prevent the filler from filling the pores as it should and allows moisture to be absorbed, either of which has a tendency to cause shrinkage. Impurities in the stain and improper drying of the stain are two other possible causes.

Probably improper filling, as a result of a poor grade of paste wood filler, careless methods, presence of dust or glue in the pores and soft, spongy veneer, is the cause of more shrinkage troubles than all other causes combined. The filler should be of a good quality, so designed as to dry hard and not shrink with age. The pores should be carefully filled flush with the surrounding surface and the filler should be dried perfectly before the coats are applied. Of course, if the under coats of finishing materials are not thoroughly dry before succeeding coats are applied there is also danger of shrinkage as well as cracking and checking when these coats do become thoroughly hard. Shrinkage in lacquer finishes is often due to rubbing the finish before the solvents have evaporated sufficiently. Later, when more of the solvents evaporate, the entire film shrinks in thickness but there is greater shrinkage over the pores because the film of lacquer is thicker there. Plenty of drying time

between coats of lacquer and especially after the last coat will reduce shrinkage troubles in lacquer finishes.

SIENNA. See *Raw Sienna*.

SILEX. One of the forms of silica, used extensively in the manufacture of paste wood fillers. The uneven jagged edges of the crystalline structure gives this material good sticking properties, making it more difficult to wipe the filler out of the pores of the wood. It is chemically inert and does not shrink or absorb moisture.

SILICA. One of the inert pigments used extensively in the manufacture of paste wood fillers. It is transparent, hard and inert to acids, alkalies, heat and light. It has a tendency to settle hard but is unsurpassed by imparting adhesive qualities to paint. It consists essentially of silicon dioxide.

SILICATE OF SODA. A white powdery substance, as obtained commercially, which is soluble in water and dries to a transparent hard film when exposed to the air. For this reason it is sometimes called "water glass."

SILKING. Silking resembles hair lines, showing only in the direction of flow of the work and noticed mostly when the material is poured over a smooth surface or applied by flow coating. It is a defect on some finishes that are applied by dipping or by flowing, but does not usually show when brushed or sprayed. This term is also used to express a slight color float which sometimes shows up on baked enamel work.

SILK SCREEN STENCIL LACQUERS. Lacquer materials which are applied through a tightly drawn silk of fine mesh and used to transfer lettering, designs, etc., onto a surface. Such lacquers are high in solid content and of a reasonably heavy consistency to permit the application by means of a rubber squeegee.

SILT. Very finely divided particles which are sometimes scarcely visible to the naked eye unless the finishing material is held in a glass tube in the proper light. This silt will settle out of varnish if allowed to stand sufficiently long but in many cases is so fine that it cannot be removed by filtering or clarifying. Silting also describes the settling out of the pigment in a film so a thin film of vehicle is left on the surface.

SILVER LEAF. A thin leaf made of pure silver used for lettering on gloss (Note: Aluminum is used where silver color is desired on wood or metal surfaces as silver leaf would tarnish) formerly mostly manufactured in Germany, but now a Superior Extra Thin product is produced in the U. S. Usually $3\frac{3}{8}$ " square and packed in books of 25 leaves each, 20 books to a "pack."

SINGAPORE DAMMAR. That grade of dammar which has its source in the British protectorate, Singapore. It is slightly harder than Batavia dammar.

SINKING IN. A finishing material is said to sink in when it is applied over a porous undercoat so that considerable of it is absorbed by the undercoat.

SIZE. A size is a solution of gelatinous material, such as glue, starch or resin, which is used to seal or fill the pores of a surface and consequently hold out succeeding coats of finishing materials. Also a sticky liquid used to attach

gold leaf or bronze powders to a surface. Also a stiffening material for fabric or paper.

SKINNING. This term is not applied to lacquers. Some varnishes have a tendency to skin over when left exposed to the air in an open vessel, or in a partially filled container. Later when such varnish is forced through the spray gun, the air breaks the skin into a number of particles which appear on the work as specks. This condition can be overcome by straining the varnish and by taking care to store it in completely filled containers. A thin film of turpentine over the top of the varnish will prevent it from skinning over.

SKIN TROUBLES. Certain individuals are more susceptible to skin troubles from contact with lacquers and similar materials than others. This question was thoroughly investigated during the World War by the Scientific Section of the National Paint, Varnish and Lacquer Association, and tests indicated the following salve to be very helpful in preventing trouble of this kind; Lanolin, petrolatum, stearine and glycerine, 25 parts each by weight.

This salve should be rubbed into the skin on the hands and arms before starting work, and is not rapidly attacked by solvents. After washing up at night the workmen may rub a little more of the salve on the skin, which keeps it in good condition.

It should be borne in mind that pimples, skin eruptions, etc., which come in contact with solvents are usually not caused by the solvent itself, but are caused by the opening of the pores, which makes the skin more susceptible to ordinary infection from dust and dirt, and it is to these causes primarily that the trouble is traceable.

SKIPS. Uncoated places in the finished surface left bare by mistake.

SLIPPERY. (Anglo-Saxon, *slipan*) Applied to a surface over which objects readily slip or slide. A smooth and well-lubricated surface is slippery. (Journal of Rheology.)

SLOW EVAPORATING. High end-point solvents (liquids) used in coatings to increase the flow.

SLUSH. To apply a finishing material roughly by dipping, spraying or brushing, such as slushing the wooden frame of an automobile body. Slush oils are coatings on steel or other metals. Pumice slush is the wet finely divided residue produced by rubbing.

SMALT. Finely divided glass used for application to freshly coated surfaces for decorative effects.

SMOKY. When the finish shows a cloudy look and does not polish out clean and bright it is said to look smoky.

SOFT. Easily penetrated by a hard object. The opposite of hard.

SOFTENERS. High boiling or low vapor pressure materials added to lacquers to increase the elasticity or toughness of the dried film. See *Plasticiser*.

SOFTNESS. (Anglo-Saxon, *softe*) The opposite of hardness. A soft substance is easily deformed without a fracture. Contrast with brittleness. It is not identical with weakness; for example, a soft pencil lead may possess considerable strength. (Journal of Rheology.)

- SOLID.** (Latin, solidus, dense) A solid, in contradistinction to a fluid, is a substance which will continuously resist deformation provided that the shearing stress is below a certain value. At shearing stresses below the yield value the deformation consists of the temporary elastic deformation and the permanent pseudo-plastic deformation. (Journal of Rheology.)
- SOLID COVERING.** A material is said to be solid covering when it covers up or hides the surface beneath it — in other words, when it produces an opaque film.
- SOLIGEN DRIERS.** Solutions of the drying metal salts of certain acids, e.g., cobalt (naphthenate or similar), dissolved in an organic solvent.
- SOLUBILITY.** The conventional definition of solubility is the percentage of dissolved substance contained in a saturated solution at a given temperature. But the term cannot be given the conventional definition when it is applied to colloids for the following reasons: Saturated solutions of colloids cannot in general be prepared, and the solutions are quite different from ordinary solutions in that they do not obey the laws of true solutions as regards osmotic pressure, vapor pressure, freezing point, etc. Colloidal solutions are not true solutions but fine dispersions, with the particles of the solute of more than molecular magnitude. A good solvent is a medium which disperses a given colloid to give a material of low consistency. Thus acetone is a good dispersing agent for nitrocellulose whereas benzene is a non-dispersing agent or non-solvent. So colloidal solubility may be defined as the percentage concentration of colloid required to give a yield value when brought into solution at a given temperature. Generally speaking, the colloidal solubility increases with the temperature. (Journal of Rheology.)
- SOLUTION.** A homogeneous mixture, the proportion of whose constituents may be varied within certain limits. A solid matter is said to be in solution or peptized when the molecules of a liquid have exceeded the attraction of those of a solid. (Journal of Rheology.)
- SOLVENCY.** The ability to reduce (lower the viscosity) and to permit tolerance with cheaper diluents.
- SOLVENT.** A liquid that is capable of dissolving any given material is referred to as a solvent for that material.
- SOLVENT NAPHTHA.** A volatile thinner which is obtained by the distillation of coal tar. It is somewhat similar to benzene except it has a higher specific gravity, a higher flash point, a higher boiling point and is more volatile. See *Naphtha*.
- SOLVENT TOLERANCE.** A heavy body liquid has a great degree of tolerance in order to permit application (reduction). Also applied to a "hungry" finish in which a rich mixture is required.
- SORTS.** One of the size gradings of various gums, referring to rather large pieces which have been sorted for color or other properties and are practically free from dust, dirt and small pieces of gum.
- SOYBEAN OIL.** Obtained from the soybean.
- SPATULA.** A long, flexible bladed knife used for mixing colors and for similar purposes.

SPECIFIC GRAVITY. The weight belonging to an equal bulk of every different substance. The standard for specific gravities of solids and liquids is pure distilled water at the temperature of 62°F, which is reckoned as unity, and by comparing the weights of equal bulks of other gravities. Specific gravity may be determined by a number of methods but the one most commonly used for liquids is the insertion of a hydrometer into the liquid which indicates the specific gravity according to how far the hydrometer sinks into the liquid.

There are several other scales of comparative weights of equal volumes which have other materials than pure distilled water as their standard. One of these more commonly known scales is the Baumé scale, which is subdivided into one scale for liquids lighter than water and another for liquids heavier than water.

Specific Gravity may be converted into the weight per gallon of the liquid by multiplying the specific gravity reading by the factor 8.33, which is the weight in pounds of a gallon of pure water.

SPECTROPHOTOMETER. A mechanical device which is used to break apart into the colors of the spectrum the components of the lacquer being analyzed. See *Color Analyzer*, also see *Colorimeter*.

SPIDER LEGS. When the coated material on an upright surface separates or breaks and the vehicle runs down in long, crooked channels, the defect is called spider legs. See *Breaking*.

SPIRIT STAINS. Stains made by dissolving dye matter in alcohol and similar solvents.

SPIRIT VARNISHES. Solutions of gum-resin in volatile liquids, usually produced without heat. Spirit varnishes formerly consisted almost entirely of alcoholic solutions of gums, but today other volatile solvents are also used.

SPIRITS OF TURPENTINE. A volatile thinner used in the manufacture of paint and varnish and by painters for reducing prepared paints to the desired consistency or in mixing their own paints upon the job. Produced by distilling the gum obtained by wounding living pine trees. The thinner obtained by the steam distillation process, from stumps, branches, etc., of dead trees, is known as steam distilled wood turpentine, while destructively distilled wood turpentine is one of the products of the destructive distillation of pine wood for charcoal, tar, pitch, etc.

SPLIT. When a clear finishing material separates into two or more distinct parts upon standing it is said to split. Also an expression in the leather industry and certain types of such lacquers are referred to as split finishes.

SPONGES. Sponges and chamois skin are very important adjuncts in any finishing room since they are used so extensively for cleaning up the job prior to applying the last coats. They must be carefully preserved or they soon become useless.

The sponges should be of good quality, tough fibre, yet soft and absorbent to take up plenty of water and not scratch the surfaces on which they are used. Each time a sponge is used it should be carefully washed in clean water and if it is sufficiently dirty, it should be washed in a soap solution, followed by

- a thorough rinsing in clean water. It should then be allowed to dry and be put away until needed again, where it will not accumulate dust and dirt.
- SPOT DRY TIME.** The drying time required for volatile materials when poured on absorbent paper (filter paper).
- SPOTTING.** The formation of off-colored places on a finish due to water spotting or other causes. Spotting can be removed by washing with cold, clean water, drying the surface thoroughly and exposing the job to the sunlight.
- SPOTTY DRYING.** Usually the result of waxy particles on a surface over which lacquer is applied. Wax may be deposited through the use of a remover.
- SPRAY GUN.** A mechanical hand machine used for applying coating materials whereby the materials are forced through a barrel arrangement by compressed air and atomized to permit application in minute particle size.
- SPRAY GUN TROUBLES.** Many difficulties that are adjusted are termed gun-troubles, i.e., insufficient pressure, water in the line, clogged gun, too heavy material, etc. These troubles present unsatisfactory work and, as mentioned, are adjustable.
- SPRAYING.** When finishing materials are applied by means of compressed air through a spray gun, which breaks up the material into a fine mist and blows it onto the work, the method of application is referred to as spraying. The term is also used to designate the method of application to be used, as, a spraying lacquer.
- SPREADING RATE.** The spreading rate of a finishing material is the amount of surface or area a given volume can be spread over by brushing, spraying or other methods of application. Usually expressed in square feet covered per gallon.
- SQUEEGEE COAT.** An application of lacquer or similar materials which are very heavy in consistency or body and are applied by means of a rubber gasket or squeegee. Broom handle lacquers are usually coated in this manner, where the handle is drawn through an insertion in a rubber. Press printing or silk screen work is also in this class, being applied by pressing with a rubber squeegee across the surface where it is impressed through a silk screen.
- STAIN.** A stain is differentiated from a lacquer or an enamel in that the colors are usually soluble in the liquid and also in that stains are used almost exclusively on wood where they sink into the fibres of the wood to a certain extent, while lacquers and similar materials lie on top of the wood.
- STAIN BLEEDING.** Oftentimes a clear or an enamel coating as applied over certain type stains will "bleed" through the coating. This action may be partially retarded by a shellac coat.
- STANDARD.** A material is up to standard or matches the standard when it meets the specification as to color, consistency, drying time and other properties of qualities as previously established as a basis of comparison. Samples are retained for match purposes and are equaled in every characteristic.
- STAND OIL.** This term is currently applied in this country to a combination of three parts linseed oil and one part wood oil, cooked together. Originally, however, it was selected linseed oil which was allowed to "stand" from

seven to ten years, during which time a natural polymerization took place, forming an oil of exceptional toughness and resistance. The Dutch "Standolie" and German "Standol" are counterparts of the English expression which have been in use for hundreds of years, antedating the introduction and use of wood oil. The "standing" process, however, has been replaced in Europe, as here, by the well known cooking methods, while the original designation still applies to these modern cooked oils.

STEAM DISTILLATION. Sometimes a jet of steam is passed through the retort while heat is being applied to the material being distilled and certain ingredients will be carried over along with the steam at lower temperatures than otherwise would be the case, thus preventing decomposition to a great extent. Such a process is called steam distillation.

STEAM DISTILLED WOOD TURPENTINE. Obtained by steam distillation of shredded chips from stumps and branches of dead pine trees.

STEEL WOOL. Steel wool or steel shavings are used to advantage in the paint shop for removing old finishes, cleaning off rust, rough surfaces, etc. It is obtained in various degrees of fineness ranging from 000, which is the finest, to No. 5, which is very coarse.

STICK SHELLAC. Shellac in a solid stick-like form which is used for repairing deep imperfections of furniture.

STIFF. When a finishing material works hard under the brush or has high viscosity it is said to be stiff.

STIFFNESS. (Anglo-Saxon, *stif*) The measure of the resistance to continuous deformation in a solid in excess of the yield value. The reciprocal of mobility. Characteristic of the glutinous substances such as glue, rubber. Quantitative: The stiffness is measured by the shearing stress in dynes per square centimeter in excess of the yield value, required to shear either of two parallel planes one centimeter apart, with a velocity of one centimeter per second, the space between being filled with the plastic material. Stiffness is a more general term than viscosity, the latter being the stiffness when the yield value is zero. (*Journal of Rheology*.)

STIMULATOR. Certain pigments help to promote rusting of iron and steel due to their chemical or electric properties, and such pigments are referred to as rust stimulators. See *Corrosion*.

STIPPLE LACQUER. A very heavy viscous nitrocellulose product which may be applied by spray gun application, which is involved in low air pressure or may be applied in much the same manner as a point stipple, i.e., by brush or newspaper.

STIPPLED FINISH. A rough or stippled finish effect used on wood, metal, etc. There are both the lacquer type described under stipple lacquers, also paint materials which are applied with a stippling brush or by twisting a crumpled paper to various designed effects.

STOCK. The word stock is used to describe the thickness of finishing material applied to the work. If it is applied too thin, it is said that there is not enough stock on the work.

- STONE MILL. A paint grinding mill which depends upon the flat pieces of roughened stone, one stationary, the other revolving, between which the paste, in the course of being "ground," must pass.
- STOP OFF ENAMEL. Enamels used in the plating industry and used during the plating operation.
- STREAKED FINISH. A condition of a finish usually caused by improper adjustment of the spray gun.
- STRENGTH. The strength of a pigment is its opacity or tinting power.
The maximum stress required to overcome the cohesion of a material.
Quantitative: A complex property made up of tensile strength and shearing strength. The force required to break a bar of unit cross-section under tension, that is, the tensile strength, depends not only upon the cohesion but also upon the consistency and therefore at least to some extent upon the rate of application of the load. Strength involves the idea of resistance to rupture. Distinction may be made between tensile strength and compressive strength. (Journal of Rheology.)
- STRIKE. When coloring materials are precipitated upon inert bases they are said to be struck and the process of depositing the color upon such a base is called striking.
- STRIKING IN. A finishing material is said to "strike in" when it softens the undercoats and sinks into them slightly.
- STRING. A finishing material is said to string or to be stringy when a partially hardened film of it strings out to a thin thread when stretched instead of snapping off short.
- STYRENE. A product of liquid storax. Styrene is a highly refracting pale yellow to colorless liquid, the presence of which gives characteristic odor to illuminating gas.
- SUCCINIC ACID. A white crystalline structure used in the manufacture of synthetic resins.
- SUCTION. The suction of a surface is its porosity which causes it to rapidly absorb a freshly applied coat of finishing material.
- SUNDAYS. Skipped places caused by failure to entirely cover the surface at the time of application of the finishing material. Just another term for *Holidays*.
- SUNFLOWER SEED OIL. Obtained from the sunflower seed.
- SURFACE. A term which may be used to express the kind of surface to be coated, or the kind of surface obtained after the finished work has been rubbed. One is said to surface the work when he rubs it to a smooth and level finish.
- SURFACE DRYING. When a finishing material dries on top and remains more or less soft on the bottom, it is said to top dry or surface dry.
- SURFACE GILDING. Applying Gold Leaf to the surface of wood, stone or metal.
- SURFACER. Any finishing material which is used to build up a surface or to aid in producing a smoother surface may be called a surfacer, although the name applies more particularly to products such as sanding surfacer, rough stuff,

intermediate sealers, glazing putty, etc. Surfacer of this type usually contain considerable amounts of pigment to give good filling properties and after being dried and sanded are rubbed to a smooth surface before succeeding coats are applied. Paint surfacers usually are force dried.

With the advent of lacquer enamels it was necessary to develop a paint sur-
facer that was not readily affected by the lacquer solvents. This has been
done remarkably well and such sanding surfacers are now commercially avail-
able — surfacers which may be recoated each five hours, water sanded in five
hours after the last coat and coated with lacquer enamel within an hour or
so after rubbing. This speeds up the schedule to a great extent. In motor
car production such products are force dried or baked.

Lacquer surfacers are available which may be recoated each half hour and
water sanded after the last coat has remained overnight. Some of these are
very durable but none fill the imperfections in the metal quite as well as the
paint surfer or rough stuff and they are usually tougher to sand. For use
under lacquer enamels on metal that is not too heavily file marked, they have
a very important place.

SURFACE TENSION. The property of liquids which causes them to try to
diminish their surface.

The attractive force of a surface measured along the unit of its edge. (*Journal of Rheology.*)

SWEATING. When a finishing material (especially a varnish) becomes more
or less glossy after it is dull rubbed, it is said to sweat. It should be borne
in mind, however, that practically all dull rubbing varnishes can be polished
to some extent, due to the fact that they are short in oil content and con-
tain gums that take a polish. This polishing effect from friction should
not be confused with sweating. Sweating is caused by rubbing the varnish
before it is sufficiently dry.

Trouble from this cause will be increased if the varnish has been piled
on too heavily and is not dry all the way through. The use of pumice stone
which is too fine will also tend to produce sweating. Likewise too much fric-
tion at the time of rubbing may heat up the coating and cause it to sweat.

SWELLING SOLVENT. When a liquid (solvent) is added to a mixture and an
extension takes place rather than a reduction, it is said to be a swelling
solvent. Such is the action of benzol or toluol on nitrocellulose cut in ethyl
acetate.

SYNERESIS. Syneresis is the opposite of swelling. Gels, which expel a liquid
solvent, become smaller in size while the liquid solvent increases in amount.
The expelled liquid solvent represents the syneresis liquid solvent.

SYNTHETIC. Synthesis: Putting two or more things together — deducing and
combining complex ideas from simple ones. (*Webster's Dictionary.*)

SYNTHETIC RESIN. Resins prepared by artificial means. Some of the syn-
thetic resins are ester gum, and others are of the phenol formaldehyde and
phthalic anhydride types.

The synthesis from which the word synthetic is derived means the building

up of a complex body from simple elements. The term resin was originally applied exclusively to a group of natural or fossil resins. Synthetic resins are those products which are obtained artificially by a systematic exploitation of chemical reactions of organic substances which produce resins similar or superior to natural resins in both characteristics and properties.

TACK FREE. A term meaning that the stickiness of the film has passed and the surface can be touched with the point of the finger without any of the finishing material clinging to it.

TACKINESS. The stickiness of the film of lacquer and similar materials while in the stage of drying. After a paint or varnish sets up it usually retains a sticky or tacky feel for some time until it is practically dry.

(Breton, tack, tach) Stickiness. A quality possessed by a solid having a low yield value and high mobility, by means of which contact readily results in adhesion; for example, glue, varnish, printer's ink and gold size under working conditions are tacky or sticky substances. When a material dries out, sets up or gels, or hardens due to chemical or other change it loses tack or stickiness. (Journal of Rheology.)

TALC. A flaky or fibrous form of hydrated aluminum silicate used as an extender in finishing materials and to prevent other pigments from settling hard.

TARNISH. To lessen the lustre by stain or oxidation. A good prevention of tarnish on metal is to coat with clear metal lacquer.

TEARS. Small drops of finishing materials formed by the collection on edges when applied by flowing, such as explained under "drips" and "tits." Also caused by bubbles in a finishing coat which flow down part way then break, leaving a little drop or rounded globule on the bottom edge. Also used in connection with a type of fossil gum resin.

TEMPERATURE CHECKING. One of the most important requisites of finishes as applied to furniture. Also referred to as "cold checking." It is a film rupture at an angle to the run-of-the-grain.

TENSILE STRENGTH. The resistance of a coating film to distortion.

TENSION. The expansive or elastic force of a coating film.

TERRA ALBA. One of the popular names for the inert pigment gypsum.

TESTED MATERIALS. Raw materials and finished products which have been approved for use by control laboratory or in production.

TEST PANELS. Wood or metal panels on which surface coatings are applied for testing purposes.

TEST RACK. A frame rack used to place coated panels for testing purposes (exposure).

THERMOPLASTICITY. The property of changing from the soluble and/or fusible state to the insoluble and/or infusible state when sufficient heat is applied, e.g., molding Bakelite articles by application of heat and pressure to the initial fusible Bakelite resin.

THERMOMETER. A thermometer is an instrument for measuring the quantity of heat. Several scales are used on thermometers, the most common one being the Fahrenheit scale which places the freezing of pure water at 32 degrees and the boiling point of pure water at sea level at 212 degrees. On the centigrade scale the freezing point of pure water is 0 degrees and the boiling point is 100 degrees. The following formulas can be used to convert the reading on one scale to another:

Fahrenheit to Centigrade:

$$C = (F - 32) \frac{5}{9}$$

Centigrade to Fahrenheit:

$$F = 9C/5 + 32$$

THICK. A liquid is said to be thick when it has a stiff or heavy consistency.

THICKEN. Opposed to thin. To increase the consistency of a material. (Journal of Rheology.)

THICKNESS OF FILM. The body on the work after the film of finishing material has thoroughly dried.

THINNER. This term is used to express the consistency of a material such as when speaking of a thinner body or consistency. The term is also used to denote the general group of volatile liquids used for thinning or reducing any lacquer or allied product. See *Reducer*.

THREE-QUARTER GLOSS. Not quite a full gloss. A term used in conjunction with furniture finishes.

THUMBNAIL PROOF. The determination of degree of hardness of a finish by testing with the thumbnail.

TIFFANY FINISH. A multicolored, rough texture, satin lustre finish used greatly for decorating walls of public buildings and of large homes. The finish is brought up in the usual manner and the last coat pounded with a ball of cheese cloth before it is dry. The final coat consists of patches of various colored semi-transparent colors of harmonizing shades, wiped into each other to produce blended and high lighted effects and then pounded with a ball of cheese cloth to thoroughly blend the colors.

TINT. The tint of a material designates the quality of color in it and in general use refers to a light variety of a color, that is, one containing large quantities of white pigment and only small quantities of the strong coloring agent. When used as a verb the word "tint" indicates the act of adding small quantities of color, as for example a white lacquer enamel is tinted to an ivory shade by adding a small quantity of yellow.

TINTING COLORS. Straight color bases of concentrated strength used to tint lacquers, etc.

TINTING STRENGTH. The tinting strength of a pigment or color is its ability to change the color of a lacquer or similar material having a different color than that of the color being tested. Colored pigments are usually tested for their ability to tint a white and white pigments are tested for their ability to tint an ultramarine blue or similar colored lacquer. The usual method for

testing colored pigments is to weigh two grams of a standard zinc oxide pigment and .20 grams of the colored pigment being tested. Then add a definite amount of a standard oil (castor oil is frequently used), usually 20 to 30 drops from a pipette; rub the mixture with a definite number of strokes on a heavy marble or glass slab with a glass pestle until a shade is formed. Spread the paste on a thin glass slide alongside of a similar paste made with equal amounts of a standard sample of the same pigment as being tested. These two samples of paste should be so placed on the glass slide that their edges adjoin. The color is observed through the back of the glass. The darker shade shows the colored pigment which has the stronger tinting power. In the case of white pigments, the lighter of the two shades shows the white pigment of the stronger tinting power. The testing glass should be perfectly clear and transparent with no greenish cast.

The pigment should always be tested against the same standard sample and the same quantities of the pigment should be used for testing the same color, although the quantities may be varied as seems best when testing different colors. The same quantity of oil should be used and the same number of strokes of the pestle. Failure to observe any one of these precautions may give erroneous results.

TINTOMETER. An instrument for measuring the intensity of color in a lacquer or similar material.

TITANATED LITHOPONE. A co-precipitated pigment consisting of about 85 per cent lithopone and 15 per cent titanium dioxide.

TITANIUM DIOXIDE. (TiO_2) This is a white pigment with a very high refractive index and great hiding power which has come into extensive use during the past fifteen or twenty years. Except for special purposes, where maximum hiding power with a minimum pigment content is desired, it is usually used in combination with other pigments. See *Titanium Pigments*.

TITANIUM PIGMENTS. These include the pure titanium oxide and the composite pigments in which the titanium dioxide is co-precipitated and coalesced with blanc fixe (barium sulphate) or calcium sulphate; also the latest member of this series, lead titanate. The composite pigments have greater hiding power than mechanical mixtures of the same proportions, 25 per cent titanium dioxide and 75 per cent blanc fixe, and 30 per cent titanium dioxide and 70 per cent calcium sulphate. The titanium pigments have found a wide range of usefulness in both exterior and interior paint formulation, as well as enamels and lacquers.

TITS. Small drops of material usually collected near the bottom edge of dipped or flowed work. Another term for the same as described under *Drips and Tears*.

TOLERANCE. Toleration for, i.e., non-solvent has certain tolerance for lacquer before the cellulose nitrate is precipitated.

TOLUIDINE RED. A brilliant non-bleeding red pigment made by coupling beta naphthol with meta-nitro-ortho-toluidine.

TOLUOL. A coal tar hydrocarbon used in resin solutions and lacquers.

- TONERS.** Chemical colors which are pure dyestuffs ground into pigment and processed to make them substantially insoluble in a vehicle.
- TOUGHNESS.** (Anglo-Saxon, *toh*, tough.) The ability to withstand large and sustained shearing stresses without yielding. Toughness involves low mobility (or fluidity) and adequate yield value. Automatically ascertained cohesion is involved. See also tackiness, length and shortness. The opposite of brittleness. (Journal of Rheology.)
- TOXICITY.** The condition of an effect on a human by inhalation of fumes. Benzol, a coal tar hydrocarbon, is a toxic solvent.
- TOY AND NOVELTY LACQUERS.** Lacquers employed in coating toys or similar novelties (usually of heavy bodied, dipping type).
- TRIACETIN.** (Glyceryl Triacetate) A water white liquid, odorless, used as a plasticiser in cellulose acetate lacquers.
- TRIETHANOLAMINE.** A viscous liquid, ammoniacal odor, used as an emulsifying agent.
- TRICRESYLPHOSPHATE.** A high grade plasticiser used in lacquer manufacture.
- TUBE BODY.** The consistency or viscosity of a liquid as noted by the speed with which an air bubble rises through the material in calibrated glass tubes.
- TUMBLE FINISH.** A coating applied through use of tumbling barrels which is rotated and material applied in this manner.
- TUMBLING.** Small objects are sometimes coated in large quantities at one time by throwing them into an inclined keg or barrel with a small quantity of the finishing material. As the barrel rolls around and around, the objects come in contact with the finishing material and with each other so that a thin coating is applied. This is called tumbling. Wooden barrels revolving on a center axis are sometimes used.
- TUNG OIL.** Also known as chinawood oil. An oil extracted from the nut of the tung tree. Characterized by rapid drying and used largely in the manufacture of varnish. See *Chinawood Oil*.
- TURBIDITY.** Opaque with finely divided suspended matter. A finishing material shows turbidity when its clearness is disturbed by reason of small particles of sediment being mixed throughout the mass.
- TURPENTINE.** Strictly speaking, this term applies only to the gum obtained by wounding living pine trees and which is distilled to yield gum spirits of turpentine and rosin. However, the term is commonly used to denote the volatile portion which is widely used as a paint and varnish thinner. See *Spirits of Turpentine*.
- TURPENTINE SUBSTITUTE.** Usually prepared from suitable refractions of petroleum by the distillation process. Used largely to replace turpentine as a volatile thinner in paint and varnish. The physical properties such as specific gravity, flash point and solvent power vary considerably in turpentine substitutes but these properties are rather easily controlled so that there are now on the market many turpentine substitutes which are well adapted for this purpose.

TUSCAN RED. A red pigment made from a mixture of iron oxide and an alizarine dye. A typical analysis is: Alizarine, 20%; Barium Sulphate, 43%; Ferric Oxide, 33%, and Silica and Silicates, 4%.

ULTRAMARINE BLUE. One of the blue pigments made by heating definite mixtures of china clay, sodium carbonate, sulphur and carbon. It is easily affected by acids but not by alkalis.

ULTRA-VIOLET LIGHT. Light which has a shorter wave length than the violet rays in the spectrum. Ultra-violet light is invisible and produces no color but has an active chemical effect on finishing materials.

ULTRA-VIOLET RESISTANT. A finishing material is said to be resistant to the action of ultra-violet light when it contains a filter (similar to synthetic resins which do not permit the passage of ultra-violet light through the film). Certain modified lacquers and synthetic varnishes are now in this class of coating material.

UMBER. See *Raw Umber*.

UNDERBAKED. When a material is not baked sufficiently long or at too low temperatures to give a hard film it is said to be underbaked.

UNDERCOATS. Undercoats are considered to be those materials which are applied prior to the finishing or final coats. In general they include the primer and the surfacing materials, although in some instances the color coats (varnish) are also considered as undercoats. Undercoating materials may be either clear or colored; most usually referred to as the latter, however.

UNDERCOAT TROUBLES. Faults directly attributed to undercoat materials. A common undercoat trouble is insufficiently dried undercoats.

UNDERTONE. The undertone of a finishing material is the color which is observed through and modifying another color.

UNSAAPONIFIABLE MATTER. The substance contained in fats and resins which does not unite with caustic alkali to form a soap.

UREA FORMALDEHYDE RESINS. Products which are obtained by the chemical reaction between urea and formaldehyde in the presence of acid or alkaline catalysts. This type of compound is receiving recognition in the synthetic finish field.

UNSEASONED. Not thoroughly dry or otherwise ready to receive a coat of finishing material.

VACATIONS. Skipped or uncoated places in the finished work are sometimes referred to as vacations. See *Holidays*.

VANDYKE BROWN. Although of organic rather than inorganic composition, Vandyke brown is found in certain deposits in Europe. Artificial Vandyke brown is made by heating the bark of trees and other ingredients together with the exclusion of air. Vandyke brown is very weak in hiding power and is used mostly in staining and graining.

VAPORIZE. To convert into vapor.

VARNISH. Varnish, as it is known today, may be defined as a fluid which dries in contact with air by evaporation of its volatile constituents, by the oxidation of its oil and resin ingredients, or by both methods, to a continuous protective coating, when spread upon a surface in a thin film. Varnish always contains resin except in very few special cases such as patent leather varnishes, litho varnishes and the like. It may or may not contain oil, driers and volatile thinners, although it frequently contains all of these materials. It may dry either with a high lustre or with practically no lustre at all.

VARNISH SKINS. Some varnishes have a tendency to skin over when left exposed to the air for a considerable length of time in an open vessel or a partially filled container. This is especially true in varnishes containing a large percentage of chinawood oil (tung oil), and particularly when the oil has been improperly tested.

Later, when such varnish is forced through the spray gun the air breaks the skin into a great number of particles which appear on the work as specks. This condition can be overcome by straining the varnish and by taking care to store it in completely filled containers. A thin film of turpentine over the varnish will prevent it from skinning for some time. This is especially effective when trouble has been experienced with skinning in dip tanks.

Another cause of skinning is found where varnish heaters form a part of the spraying equipment. Oftentimes the heaters are neglected over long periods of time and frequently the temperature goes much too high. As a result, a part of the varnish is volatilized as it passes through the heater and is condensed again in the cooler parts of the outfit. Later this accumulation may become loosened and get into the varnish, being carried along to the spray gun where it is broken up still further and deposited upon the work in the form of skins.

The obvious remedy in this case is to water the heaters more closely and keep the temperature down to not more than 100-110°F. Indeed, there is some question as to the advisability of using varnish heaters at any time on account of the close attention they require and because of the fact that varnishes have now been developed that level out and give good body on the work when applied at ordinary room temperatures. Much the same unsatisfactory results as those coming from varnish skins are sometimes found where varnish is sanded before it is thoroughly dry on account of being applied too heavily or because of unsatisfactory drying conditions. When "green varnish" such as this is sanded too vigorously it becomes heated and rolls up under the sandpaper. Some of these little particles of varnish become imbedded in the partially dried varnish due to the pressure and heat accompanying the sanding operation and are unknowingly left adhering to the surface during the dusting operation before the next coat of varnish is applied.

When the next coat of varnish is applied the solvent action of the reducers in the varnish is great enough to loosen up many of these particles, causing them to show up in much the same form as varnish skins.

The remedy in cases of this kind is obvious. The varnish should be applied

in such a manner that it dries evenly throughout and not "mushy" or soft in some spots and hard in others. The drying conditions should be such that the film of varnish is thoroughly dried from top to bottom and not on top alone, and sufficient time should be allowed for this result to be accomplished. Furthermore, the sanders should use more care in sanding and not burn any loosened particles in the varnish film. Water sanding with waterproof sandpaper in preference to dry sanding may help this condition also.

There should be very few cases of varnish skins on the work if the varnish is handled properly before and after it gets on the work. When it is considered that varnish obtained from a reputable manufacturer is thoroughly strained and filtered as it is made and put into the storage tanks and again as it goes into the shipping packages, it is evident that skins are very seldom in the varnish as it leaves the manufacturer and are usually caused by conditions beyond his control.

VEGETABLE OILS. Oils which are obtained from various seeds or nuts of vegetable growth, some of which are trees and others of which are smaller plants, are known as vegetable oils. The vegetable oils used in paint and varnish making are primarily the so-called "drying" oils. These include linseed oil, chinawood oil (tung oil), perilla oil and some of the rarer oils such as poppy seed oil, sunflower seed oil, and hempseed oil.

In recent years more and more of the so-called "semi-drying oils" such as soybean oil, corn oil and cotton seed oil have been used. Fish oil is an animal oil that is used to some extent in the manufacture of certain paint and varnish products, especially where heat resisting is required. Some of the non-drying oils, such as castor oil, are used as softeners or plasticisers in lacquer manufacture.

VEHICLE. The liquid portion of a finishing material, consisting of the binder and volatile thinners.

VENETIAN RED. A bright red iron oxide pigment. A typical analysis of a very weak venetian red is: Ferric Oxide, 20%; Calcium Sulphate, 40%, and Calcium Carbonate, 40%. A stronger venetian red would have an analysis about as follows: Ferric Oxide, 83%, and Silica and Silicates, 17%.

VENEER. Wooden boards made by gluing thin sheets of wood together usually on a heavier piece of wood, called the core or cross banding. Usually it is only the expensive woods that are used in making the outside layer of veneer, so as to conserve the quality used. Veneer is said to have advantages over solid wood for certain work because of non-warping, etc., when properly made.

VINYLLITE. Trade name of a type of synthetic resin from vinyl chloracetate.

VISCOSIMETER. An instrument for determining the viscosity or consistency of a liquid. Viscosity should not be confused with specific gravity. Viscosity is the resistance offered by a fluid to the relative flow of its particles—in other words, it is the resistance to flowing. The internal friction of a fluid; opposite of fluidity. The specific gravity is an expression of the relative weight of a given volume of water at a given temperature. It should be thoroughly understood that the consistency or viscosity of a lacquer or similar material

has nothing to do, necessarily, with its Baumé reading or specific gravity. Viscosity and specific gravity represent two qualities of a liquid as widely different as daylight and dark, although it sometimes happens there may be an apparent connection between them.

VISCOSITY. (Latin, viscum, mistletoe) The measure of the resistance to continuous deformation in a fluid. The property of fluids by which they resist continuous deformation, especially characteristic of thick liquids like molasses or pitch. The reciprocal of fluidity.

Quantitative: The viscosity is measured by the shearing stress in dynes per square centimeter required to move either of two parallel planes, one centimeter apart relative to each other, with a velocity of one centimeter per second, the space between the planes being filled with the fluid. It is measured in poises or preferably in centipoises, the centipoise being the approximate viscosity of water at 20°C (1,005 cp). Under certain conditions every material will flow. The disturbance of solvation balance initiates jelly formation, making the solution show plasticity and viscosity anomalies as shown by Sheppard & Houck in October, 1929, *Journal of Rheology*.

VOLATILE THINNER. That liquid which easily evaporates and which is used for thinning or reducing the consistency of finishing materials for ease of application.

VOLATILE VEHICLE. That portion of the vehicle sometimes called "solvent" which evaporates as the coating dries and which holds the solids of the vehicle in solution.

WARPING. A deviation or swerving, especially noticeable in thin veneer when moisture is absorbed.

WASH COAT. A wash coat (usually referred to in connection with shellac) is a very thin solution applied over the stain to bleed and richen it or to stiffen up the wood fibres which were raised by the staining operation so they can be cut off easily by sanding. One part of a 4-pound cut of white shellac when reduced with 7 or 8 parts of denatured alcohol is about the right consistency for a wash coat.

WATER COLORS. Colors mixed with or ground in water are water colors.

WATER GLASS. This is a common name for silicate of soda, because the dry powder is soluble in water and when exposed to the air it dries to a hard transparent film resembling that of glass. Sometimes used for hardening concrete floors and for similar specific purposes.

WATER SPOTTING. An expression used to indicate a spotty change in the color of enamels, due to the presence of water which has either dissolved some ingredient of the film or caused emulsification.

WATER STAIN. Coloring matter, dissolved in water, used in staining woods.

WATER WHITE. A material is said to be water white when it is as colorless as water.

WAXES. Natural substances composed of hydrogen, carbon and oxygen, and consisting chiefly of esters other than those of glycerine, or of free fatty acids,

or both. (Webster's Dictionary.) They may be of animal, vegetable or mineral origin, the so-called mineral waxes, however, differing from the true waxes in that they contain no oxygen. Used in our industry for making polishes, etc.

WEAK COLORS. A finishing material is said to be weak in color when it does not have sufficient hiding power or opacity.

WEATHEROMETER. A machine device used to determine the life of film coatings by subjection to ultra-violet light, water, etc.

WEATHER RESISTING. Finishes capable of resisting exposure to the weather.

WEIGHT. That property of a body which tends to pull it toward the center of the earth. In other words, the attraction of gravity exerted upon the object.

WHIRLING MACHINE. A machine which, after coating small objects by direct immersion, has a chamber which by centrifugal forces whirls the coated object and produces a drying action.

WHITE LEAD. [$2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$] This term is properly used to designate basic carbonate white lead, which is believed to be the oldest known white pigment, having been in continuous use for more than 2,000 years. It has excellent hiding power and durability and when used alone as the pigment in a white paint it "chalks" gradually, leaving a surface which is in good condition for repainting. White lead is commonly used in high grade exterior paints in combination with zinc oxide, with or without extenders, and with zinc oxide and titanium pigments. The use of the term "white lead" is sometimes extended to include basic lead sulphate, which, to a lesser degree, is used in much the same way as basic carbonate white lead, especially where cost is of primary importance.

WHITENING. A condition generally brought about in lacquer, varnish or shellac by the absorption of water or moisture. Some varnishes remain white only while the moisture is present in the film (the white appearance being due to a difference in the refractive index of the material and the water); other varnishes of a more unstable nature remain permanently white after coming into contact with water or moisture, due to the precipitation of waxes, fatty acids or other compounds. In lacquers, it is the precipitation of the nitrocellulose.

WHITE SHELLAC. See *Shellac*.

WHITING. One of the inert pigments produced by grinding natural English cliff stone. It consists essentially of calcium carbonate, and is used in making putty and as an extender for paints. Whiting has a tendency to give a slight alkaline reaction and consequently should be used carefully with colors.

WIND BREAK. Roughness formed on the surface of finishing materials by currents of air blowing over them while drying.

WOOD ALCOHOL. Formerly the common term for methyl alcohol, which is obtained from the destructive distillation of wood. Wood alcohol is not used to any great extent now in manufacture of lacquers and allied products due to its poisonous nature. See *Methanol*.

WOOD FILLER. Wood filler as used in furniture finishing is a paste material which, when reduced with naphtha and applied to the wood surface, allowed to stand for 15 or 20 minutes until "set," wiped off across the grain and dried, fills the pores with a hard, non-shrinking colored mass that beautifies the finish and prevents succeeding coats of finishing materials from being absorbed by the wood.

WOOD FLOUR. A fibrous structural compound used in plastics and cements.

WOOD OIL. See *Chinawood Oil* and *Tung Oil*.

WOOD ROSIN. Obtained from shredded chips of stumps, branches, etc., of dead pine trees by the steam and solvent process. The chips are digested and subjected to steam distillation which carries off the volatiles, consisting of steam distilled wood turpentine and pine oil, and the rosin is then extracted with a solvent (naphtha) which is recovered and used again. The chips from which all possible volatile material and rosin have been removed are then used for fuel.

WORKABILITY. Certain substances change in consistency during the period of application or of manufacture; for example, plaster suffers an increase in consistency as it is being applied to the walls, due to water absorption. A material shows the property of workability which is readily manageable during the operations in question. (*Journal of Rheology*.)

WRINKLE FINISH. A finishing material (varnish) which produces a wrinkle or ridged effect, available in clear and colors.

WRINKLING. A term common in the varnish industry. When applied to varnish this term describes an irregularity of the surface in the form of puckered or wrinkled places, due to too heavy varnish, too much varnish, insufficient brushing, sudden lowering of temperature or top drying of the varnish due to too much drier. See *Crinkling* and *Puckering*.

XYLOL. A coal tar distillate resembling benzol and toluol but of a higher boiling fraction, used as a non-solvent or diluent in lacquer and as a constituent of synthetic enamels.

YACCA GUM. A gum resin obtained from Australia, finding very little use in the industry today.

YELLOWING. Clear finishes and white lacquer enameled work, as well as allied products of this nature, sometimes turn yellow upon long standing; this is called yellowing. Oftentimes in using clear and whites it is common practice to add a small amount of blue tinting color to offset the tendency to yellow. Care should be taken not to add too much, however.

YIELD POINT. The minimum force starting flow of a plastic or viscid body. (In plastic body the force may be decreased without stopping flow.)

YIELD VALUE. The amount (gallonage) that a given formula yields in actual production.

ZANZIBAR. A very hard, fossilized gum-resin obtained from Zanzibar, an Eastern African Sultanate which is under British Protection. Formerly it was used quite extensively in the manufacture of high grade varnishes, but in recent years the supply has diminished to such an extent that its use is rather limited.

ZINC OXIDE. (ZnO) The second, in length of use, of the important synthetic paint pigments, zinc oxide (zinc white) was first made commercially by LeClaire in France, about one hundred years ago. The French, or indirect process, involves the smelting of the ore to produce slab zinc, which is oxidized in another furnace to produce the zinc oxide. In the American, or direct process, the zinc ore is reduced in the furnace to metal which is immediately vaporized and oxidized in one operation. White Seal, Green Seal and Red Seal are grades with properties which make them adaptable to specific types of formulations. Zinc oxide finds a wide use not only in high grade exterior house paints, but in lacquers and enamels.

ZINC SULPHIDE. (ZnS) One of the modern white pigments with high brightness and hiding power. By itself, it is used primarily in lacquers and enamels, but in combination with other pigments, it forms the base of a series of pigments which find a wide range of application. The ordinary lithopone consists of a combination of about 30 per cent zinc sulphide and 70 per cent barium sulphide which are co-precipitated, while the high strength lithopones may contain as much as 50 per cent zinc sulphide.

ZINC WHITE. See *Zinc Oxide*.

INDEX

- Abrasion** meter, use of, in testing finishes, 237; of finishes, test for, 236, 239; tester, use of, in testing finishes, 239.
- Abrasive**, definition of, 401.
- Absorb**, definition of, 401.
- Accelerate**, definition of, 401.
- Accelerated pimpling test**, motor car finishes, 255; weather tests of coatings, 281; weathering, definition of, 401.
- Acetamide**, definition of, 402.
- Acetate dope**, definition of, 402; of lime as a source of acetone, 5.
- Acetates**, definition of, 402.
- Acetic acid**, definition of, 402.
- Acetone**, definition of, 33, 402; oil, definition of, 402.
- Acetyl content of cellulose acetate**, 20; test for, 235.
- Acid etching of aluminum or its alloys**, 397; hydrometer, 214; number, definition of, 402; of oils, test for, 224; refined linseed oil, definition of, 402; resisting, definition of, 402; stain, definition of, 402; value, definition of, 402.
- Acidity of solvents**, test for, 212.
- Acids and the nitration of cotton**, 13.
- Across grain**, definition of, 402.
- Actinic rays**, definition of, 402.
- Adhesion**, definition of, 402; faults and corrections, 288; of finishes, test for, 239.
- Adhesive lacquers**, requirements of, 159.
- Absorb**, definition of, 403.
- Adulterate**, definition of, 403.
- After yellowing**, definition of, 403.
- Aging**, definition of, 403.
- Air brush**, definition of, 403; conditioners and humidity control, 272; drying, definition of, 403; drying of alkyd resins, 80; primers and surfacers, phenol type, 63; impurities and air line troubles, faults and corrections, 289; line troubles, definition of, 403; reducing valve and spraying, 322.
- Aircraft fabric and metal**, finishing of, 159.
- Alcohol**, definition of, 403; its function and manufacture, 31; print test, 244; resistance of finishes, test for, 243; resisting, definition of, 403; soluble nitrocellulose, 17; nitrocellulose and the use of shellac, 58; watered, definition of, 403; faults and corrections, 289.
- Aliphatic hydrocarbons**, definition of, 403.
- Alizarine lake**, definition of, 403.
- Alkyd resins**, 66, 403; in which the modifying agent is largely unsaturated fatty acids, 75; saturated fatty acids, 74; modified principally with natural resin acids, 74.
- Alligatoring**, definition of, 403; faults and corrections, 289.
- Alphabetical list of various types of finishes**, 157.
- Aluminum**, finishes for, 160; in bus,

- truck and street car finishing, 397;
leaf, definition of, 404; palmitate,
definition of, 404; silicate, definition
of, 404; stearate, definition of, 404.
- Amaranth lake, definition of, 404.
- Amber, definition of, 404.
- Amberol resins, 64, 82.
- Ammonium carbonate and first aid,
152.
- Amorphous, definition of, 404.
- Amyl acetate, definition of, 404; sec-
ondary, values of, 38; synthetic,
values of, 38; values of, 36; alcohol,
definition of, 404; synthetic, values
of, 37; values of, 35, 39; lactate, def-
inition of, 404; stearate, definition of,
405; tartrate, values of, 51.
- Analytical methods, laboratory tests,
205, 211.
- Anhydrous alcohol, 32; definition of,
405.
- Aniline colors, definition of, 405; oil,
definition of, 405.
- Ansol, definition of, 405.
- Anticorrosive, definition of, 405.
- Antifouling, definition of, 405.
- Antimony oxide, definition of, 405.
- Antiquing, definition of, 405.
- Application by brushing, 339; defini-
tion of, 405; dipping, 340; flow-
coating, 335; roller coating, 348; silk
screen stenciling, 351; tumbling,
347; whirling, 346; the spray method,
334; of baking finishes, 161; coatings,
321; fillers in wood finishing, 360;
stains in wood finishing, 359.
- Aroclors, 52, 405.
- Aromatic hydrocarbons, 25, 43, 405.
- Artificial resin, definition of, 405;
weathering and the testing of coat-
ings, 281.
- Asbestine, definition of, 405.
- Asphaltum, definition of, 406.
- Automobile finishes and finishing, 385.
- Availability of solvents, 26.
- Bakelite**, definition of, 65, 406.
- Baking, definition of, 290, 406; finishes
and baking ovens, 160; application
of, 161; of alkyd resins, 79; ovens
and motor car production finishes,
162; definition of, 406; of finishes,
test for, 244; temperature of alkyd
resins, 80.
- Balanced solvents, definition of, 290,
406.
- Ball mill, definition of, 133, 406.
- Balsam, definition of, 406.
- Banana liquid, definition of, 406; oil,
definition of, 406.
- Bar finish, definition of, 406.
- Barium sulphate, definition of, 406.
- Barytes, definition of, 406.
- Base, definition of, 406.
- Basic, definition of, 406.
- Batavia dammar, definition of, 407.
- Baumé, definition of, 214, 407; test,
214.
- Beckacite resins, 65.
- Beckosol resins 82.
- Behavior of colored lacquers in tin
containers, 106.
- Bell telephone laboratories impact
test for finishes, 243.
- Belting cement and leather finishes,
174.
- Bending test, definition of, 195, 407.
- Benzene, definition of, 407.
- Benzine, definition of, 407.
- Benzoic acid and non-bronzing lac-
quers, 164.
- Benzol, definition of, 43, 408; dilution
factor of thinners, test for, 222.
- Benzyl acetate, 42; alcohol, 42; ben-
zoate, 43.
- Binder, definition of, 408.
- Biting, definition of, 408.
- Bitty, definition of, 408.
- Bitumen, definition of, 408.
- Biturine, definition of, 408.
- Black and white cryptometer, 253; lake,
definition of, 408; pigments, 96;
settling of, 107; toner, definition of,
408.
- Blackness, definition of, 408.
- Blanc fixe, definition of, 408.

- Bleaching agent for walnut woods, 356; definition of, 408; lacquers, definition of, 163, 409; of shellac, 57; wood, 356.
- Bleeding, definition of, 290, 409; of pigments, test for, 93; stains, 358.
- Blending, definition of, 409; of nitro-cellulose, 195.
- Blistering and bubbling, faults and corrections, 291; definition of, 410.
- Bloom or blooming, definition of, 410.
- Bloomed surfaces, cleaning of, 292.
- Blown castor oil, 52; definition of, 410.
- Blue pigments, identification of, 93; settling of, 107; toners, 103; ultramarine, 105.
- Bluing, definition of, 410.
- Blushing, definition of, 292, 411; and dipping, 342; the use of retarders, 295; how to overcome, 295.
- Blush test number of solvents, test for, 219; of thinners, 224.
- Bodied oil, definition of, 411.
- Body, definition of, 411; on the work, faults and corrections, 295, 412.
- Bodging action, definition of, 411.
- Bog oak, definition of, 412.
- Boiled oil, definition of, 412.
- Boiling point, definition of, 412; range, definition of, 412.
- Bold, definition of, 412.
- Bond coat, definition of, 412.
- Bonderizing in motor car finishing, 392.
- Bonding action, definition of, 412; synthetic resins for, 75.
- Bone black, definition of, 96, 412; charcoal, definition of, 412; dry shellac, definition of, 412.
- Bordeaux lake pigments, 104.
- Bottom drying, definition of, 412.
- Breaking and breaking up, definition of, 412.
- Bridging, definition of, 296, 413.
- Brightness, definition of, 296, 413.
- Brilliance, definition of, 296, 413.
- Brittleness, definition of, 297, 413.
- Broom handle lacquers, requirements of, 164.
- Bronze blue pigments, 101; powder, definition of, 413.
- Bronzing lacquers, definition of, 165, 413; liquid, definition of, 413; nitro-cellulose, 16.
- Brushing, method of application, 339.
- Brushmarks, definition of, 413.
- Bubbling, definition of, 413; test, definition of, 415.
- Buffer coat, definition of, 415.
- Buffing mediums, 373; of wood finishes, 373.
- Buhr mill, definition of, 415.
- Building coater, definition of, 415.
- Bulking value, definition of, 415.
- Burlap and the padding of paste wood fillers, 361.
- Burning and burning in, definition of, 415; faults and corrections, 297.
- Burn off and refinish, motor car job, 398.
- Burnt sienna, definition of, 416; umber, definition of, 416.
- Bus finishing, 397.
- Bush kauri, definition of, 415.
- Butanol, definition of, 415.
- Butyl acetate, definition of, 37, 415; secondary, 36; acetyl ricinoleate, definition of, 415; alcohol, definition of, 35, 416; butyrate, 39; butyrene, definition of, 416; carbinol, normal, 39; carbitol, 43; cellosolve, 41; lactate, definition of, 40, 416; propionate, definition of, 37, 416; stearate, 49, tartrate, 49.
- Cabinet**, drying meter, 261.
- Cable lacquers, requirements of, 165.
- Cadmium lithopone, definition of, 416; red, definition of, 102, 416; yellow, 99.
- Cage mill, definition of, 417.
- Caking, definition of, 417; faults and corrections, 297.
- Calcined, definition of, 417.
- Calcium carbonate, definition of, 417; sulphate, definition of, 418.
- Camphor, definition of, 49, 418.

- Candelilla wax, definition of, 418.
Capryl alcohol, definition of, 418.
Carbitol, definition of, 41, 418.
Carbon black, definition of, 96, 418; dispersion of, 108.
Carbon tetrachloride, definition of, 418.
Carbonate white lead, definition of, 418.
Carmine, definition of, 418.
Carnauba wax, definition of, 418.
Carrier air conditioning system, 378.
Carrier dew point control and relative humidity, 270.
Case hardening, definition of, 297, 418.
Casket lacquers, requirements of, 165.
Castor oil, c. p. and sulfonated, 52; definition of, 419.
Catalyst, definition of, 419.
Caul boards, definition of, 419.
Caustic soda, definition of, 419.
Cedar oil, definition of, 419.
Cellulosolve acetate, 39; definition of, 38, 419.
Celluloid, definition of, 419.
Cellulose acetate, definition of, 18, 419; plasticisers for, 53; solvents for, 44; tests for, 234; acetobutyrate (Hercose "C"), 22; acetopropionate (Hercose "AP"), 23; compounds, 22; and clear metal finishes, 176; definition of, 419; nitrate, definition of, 10, 419.
Cement, cellulose, requirements of, 159; paint, definition of, 419.
Centigrade, definition of, 419.
Centrifugal clarifier, definition of, 420; type water wash exhaust system spray booth, 330.
Centrifuge method of application, 335.
Ceramic finishes, requirements of, 166.
Ceresin, definition of, 420.
Chalk, definition of, 420.
Chalkiness, faults and corrections, 297.
Chalking, definition of, 420.
Chamber's coating machine and paper coatings, 178.
Chamois skins, definition of, 420.
Change can mixer, 128.
Changes in moisture, faults and corrections, 311.
Charcoal, definition of, 420.
Chaser, definition of, 420.
Cheap finishes, definition of, 298, 420.
Check, definition of, 420.
Checking, definition of, 298, 420.
Chemical colors and their manufacture, 97; classification of, 97.
Chemically pure, definition of, 421.
Chemical resistance of phenol resins, 64; stains and the staining of wood, 358.
Chill, definition of, 421.
China and early coatings, 1; clay, definition of, 421.
Chinawood oil, definition of, 52, 421.
Chinese blue pigments, 101, 421; lacquer, 1.
Chipping, definition of, 300, 421.
Chips, definition of, 110, 421.
Chlorinated rubber (tornesit), 23.
Choice cuts of walnut woods, 370.
Chroma — as a distinguishable quality of color, 86.
Chrome green, definition of, 100, 421; orange, definition of, 421; yellow, definition of, 99, 421.
Chromium oxide, 100.
Chromometer, definition of, 422.
Circulation of air, 270, 299; within an oven, 163.
Circulating system of coatings in motor car finishing, 395.
Cissing, definition of, 422.
Citronella oil, definition of, 422.
Clarification of finishes, 136.
Classification of alkyd resins, 74.
Cleaning, improper, faults and corrections of, 307; motor car surfaces, 386; of film scrap, 20.
Clear finish, definition of, 422; tone, definition of, 422; wood lacquer, 366.
Close drying, definition of, 300, 422.
Cloudiness, definition of, 422.
Clouding, definition of, 300, 422.
Cloud point, definition of, 422.

- Coagulate, definition of, 422.
Coal oil, definition of, 422; hydrometer, 214.
Coal tar derivatives, 25; as a by product in preparation of alkyd resin, 67.
Coarse rubbing of wood finishes, 372.
Coat, definition of, 422.
Coating, definition of, 423.
Coating by dipping, 343; whirling, 346.
Cobalt blue, definition of, 423.
Cocanut oil, 52.
Coefficient of expansion, definition of, 423.
Cohesion, definition of, 300, 423.
Cold checking, definition of, 423; check testing of finishes, 245; color, definition of, 423.
Collodion, 3.
Colloidal suspension, 423.
Colloidally dispersed pigments, 110.
Colloid, definition of, 423; mills, 135.
Colophony, definition of, 423.
Color, definition of, 86, 423.
Color analyzer, definition of, 424; chip, definition of, 424; float, definition of, 300, 424.
Colored finishes for wood surfaces, 374; lacquer, manufacture of, 117.
Colorimeter, definition of, 424; Pfund, 246.
Color in Japan, 424; oil, 424; varnish, 424; water, 424; of finishes, test for, 245; off, troubles, 312; retention, definition of, 425; stability, definition of, 425; standards, definition of, 425; vision, 85.
Colors for lacquer, 87.
Combinations of alkyd resins with resins of other types such as phenol formaldehyde condensates, 75.
Commercially pure, definition of, 425.
Comparator, Hellige, 246.
Comparison of varnish and lacquer with respect to drying, 366.
Compartment can, definition of, 425.
Compatibility, definition of, 81, 301, 425.
Complementary colors, definition of, 425.
Composition leaf, definition of, 425; of lacquer, 3; of wood, 355.
Compressor and spraying, 321.
Concentration, 425.
Condensate, definition of, 425.
Condensation, definition of, 425.
Congo gum, definition of, 425.
Consistency, definition of, 301, 425.
Constant humidity room and humidity control, 272; humidity, definition of, 426.
Contraction and expansion of wood, 354; definition of, 426.
Cooling tunnel in motor car finishing operations, 388.
Copal, definition of, 426.
Copperas, definition of, 426.
Core, definition of, 426.
Corn oil, definition of, 426.
Corrections of finishing faults, 288.
Corrosion and improper cleaning of metal surfaces, 307; definition of, 426.
Corrosive, definition of, 426.
Cosmic black, definition of, 426.
Cost factor of solvents, 26.
Cotton as a chemical product of cellulose, 11; as the source of nitrocellulose, 11; linters, definition of, 426.
Cottonseed oil, 52.
Coumarone, definition of, 427.
Covering power, definition of, 301, 427.
C. P., 98, 427.
Cracker jack rub, definition of, 427.
Crack filler, definition of, 427.
Cracking, definition of, 427; process of gasoline, 31.
Crackle, definition of, 427.
Crank, planetary, type of spray coating machine, 337.
Crawling, definition of, 301, 427.
Crazing, definition of, 301, 427.
Crimping, definition of, 427.
Crinkling, definition of, 428.
Cripples, definition of, 428.
Criss cross test for finishes, 241.

- Crocking, definition of, 428.
Cross banding, definition of, 428.
Crotonic acid, definition of, 298, 428.
Crown footing, definition of, 428.
Crumbling, definition of, 428.
Cryptometer, definition of, 428; Pfund, 253.
Cryptone, definition of, 428.
Crystallizing, definition of, 168, 428.
Cured resin, definition of, 428.
Curled hair, definition of, 429.
Cut, definition of, 429.
Cutting oil, definition of, 429; up, definition of, 429.
Cycle, definition of, 429.
Cyclohexanol, 40.
Cyclohexanone, 39.
- Dammar**, definition of, 59, 429.
Dark field count method of determining particle size, 111.
Dead flat, definition of, 429.
Deadening, definition of, 429.
Debloomed oil, definition of, 429.
Decalcomania, definition of, 376, 429.
Deep, definition of, 430.
Definition of a lacquer coating, vi; synthetic enamel coating, vi.
Deflocculation, definition of, 430.
Dehydration of nitrocellulose, 13.
Denatured alcohol, definition of, 32, 430.
Density, definition of, 430.
Deoxidine in motor car surface cleaning, 387.
Depth of finish, 431.
Desirable properties of paste wood fillers, 362.
Destructive distillation, definition of, 431.
Dew point and saturated air, 269.
Diacetone, definition of, 38, 431.
Diatomaceous earth, definition of, 105, 431.
Diamyl phthalate, definition of, 50, 431.
Dibutyl phthalate, definition of, 50, 431.
- Dielectric strength, definition of, 431.
Diethyl carbonate, 38.
Diethylene glycol monobutyl ether, 43; ethyl ether, definition of, 41, 431.
Diethyl oxalate, definition of, 42, 431; phthalate, definition of, 50, 431.
Diffused light, definition of, 431.
Diisobutyl ketone, 41.
Diluents, 24, 216, 432.
Dilution ratio, definition of, 432; solvents, test for, 215; of some important solvents, 29.
Dimethyl ethyl carbinol, 35; ketone, definition of, 33, 432; phthalate, definition of, 49, 432.
Dioxan, 36.
Dipentene, definition of, 432.
Diphenylamine test for nitrocellulose solutions, 227.
Dipping, definition of, 432; by squeegee, 344; how heat and blushing affects, 342; lacquers, requirements of, 169; machine and the coating of objects, 343, 432; mechanically, 343; method of application, 340; of metal, 342; wood, 341.
Dipropyl ketone, definition of, 432.
Dirt nibs, definition of, 432; on work, faults and corrections, 302.
Dirty, definition of, 432.
Discoloration, definition of, 255, 432.
Dispersion, definition of, 432; of carbon black, 108; pigments, 107; without grinding, 109.
Distemper colors, definition of, 432.
Distillate, definition of, 432.
Distilling range, definition of, 432.
Distillation, definition of, 433; of solvents, method of running, 213; solvents, test for, 212.
Disintegration, definition of, 433.
Doctor blade, 265; test, definition of, 433.
Doolittle torsion type viscosimeter, 278.
Dope, definition of, 433.
Dope cotton, definition of, 433.
Double roller mill, 129.

- Drag, definition of, 432.
Dragon's blood, definition of, 433.
Draught test, definition of, 433.
Drawer coater finishes, requirements of, 170.
Drawout, definition of, 433.
Driers, definition of, 433; with alkyd resins, 81.
Drips, definition of, 433.
Drop black, definition of, 433.
Drum cleaning, 120.
Dry air and blushing, 294; bulb thermometer and relative humidity, 270; definition of, 434; spray, definition of, 434; to handle, definition of, 434; touch, definition of, 434.
Dryers, definition of, 434.
Drying and humidity conditions, 269; comparison of varnish and lacquer, 366, definition of, 434; meter cabinet, 261; of cotton, 12; films from the bottom, 296; finishes, test for, 260; lacquer films, 302.
Ductibility, definition of, 435.
Dull finish, definition of, 435; rubbing, definition of, 435; of wood finishes, 372.
Durability, definition of, 435.
Duraluminum, finishes for, 160.
Duraplex resins, 82.
Dust, definition of, 435; free, definition of, 435; in pores, faults and corrections, 303.
Dutch metal, definition of, 435.
Dying away, definition of, 435.
- Earth** pigments, definition of, 435.
East India gum, definition of, 436.
Effloresce, definition of, 436.
Egg shell lustre, definition of, 436.
Elastic, definition of, 436.
Elasticity, definition of, 436; and tensile strength, 274.
Elastic limit, definition of, 436.
Electrical equipment as regards fire prevention, 147.
Electro-viscometer, 280.
Elemi gum, definition of, 60, 436.
- Elongation and tensile strength apparatus, 274.
Emulsifying agent, definition of, 437.
Emulsion, definition of, 437; lacquers, requirements of, 170.
Enamel, definition of, 437; coat, definition of, 437.
Enameled surface, definition of, 437.
Enameling, definition of, 437.
Eosin, definition of, 437.
Equipment, fire, 124; for grinding, 129; manufacturing, 124.
Essential oils, definition of, 437.
Ester gum, definition of, 66, 437; of thinners, test for, 223.
Ether and alcohol as lacquer solvents, 3.
Ethoxy othylphthalate, 51.
Ethyl acetate, definition of, 34, 437; acetyl glycolate, 42; alcohol, definition of, 34, 437; ether, 32; methyl ketone, 34; oxybutyrate, 39.
Ethyl cellulose, 22; and cable coatings, 165; lactate, definition of, 39, 437.
Ethylene glycol monobutyl ether, 41; ethyl ether acetate, 39; ether, 38; methyl ether, 37; solvents and odorless lacquers, 177.
Evaporation rate of solvents, chart showing, 27, 220; test for, 219.
Examination of solvent extract from solutions, 233.
Expansion and contraction of wood, 354; definition of, 438.
Exposure rack, outdoor, 124; tests, outdoor, of coatings, 286.
Extender, definition of, 438.
Extensiometer and tensile strength, 274.
Exterior coat, definition of, 438.
Extinguisher, fire, liquefied CO₂, 142.
Extraction of residuals in solutions, 232.
- Factors**, essential to satisfactory finishes, 156.
Fade, definition of, 438.
Fading of colors (pigments), 90; test, definition of, 438.

- Fadometer, definition of, 438.
Fahrenheit, definition of, 438.
Falling ball method of determining viscosity, 276.
False body, definition of, 438.
Fast schedule, definition of, 438; to light, definition of, 90, 438.
Fat, definition of, 438.
Fatty acid, definition of, 438; edge, definition of, 438.
Faults and corrections of finishes, 288; spraying, 333.
Feathering, definition of, 439.
Felt, rubbing, 372.
Ferric ferrocyanide, definition of, 439.
Ferrous sulphate, definition of, 439.
Fibre and fabric finishes, requirements of, 177.
Figuration of wood, 355.
Filler, definition of, 360, 439; troubles, definition of, 303, 439.
Film, definition of, 439; discoloration, test for, 255; gauge, Pfund, 264; o-graph, Parks, 263; o-meter, definition of, 439; preparation, definition of, 439; ruptures and temperature change test, 383; scrap, definition of, 20, 439; spinning device, definition of, 252, 439; thickness, definition of, 263, 439.
Filter press, definition of, 136, 439.
Fineness, definition of, 439.
Fine rubbing of wood finishes, 372.
Finger marks and finishing, 302; nail test, definition of, 240, 439.
Finish coater, definition of, 440; testing machine (abrasion test), 238.
Finishes and finishing of motor car surfaces, 385.
Finishing coats in motor car operations, 392; furniture inlays, 368; lacquers, definition of, 440; operations, motor car surfaces, 386; schedule, definition of, 440; for railway coatings, 180.
Fire cracking, definition of, 440; equipment, 124; fighting dangers, 152; equipment and organization, 151; foam, definition of, 440; point, definition of, 440; prevention and protection, 141; process pigments, 105.
First aid in lacquer fires, 153; coater, definition of, 440.
Fish oil, definition of, 440.
Five roller mill, 130.
Fixed oil, definition of, 440.
Flaking, definition of, 440.
Flash point, definition of, 440; primer in motor car finishing, 389.
Flat, definition of, 440; lacquer, definition of, 366, 440; mill, definition of, 440, paint, definition of, 440.
"Flattening" of paste wood fillers, 361.
Flexibility, definition of, 304, 311, 440; of finishes, test for, 239.
Floating colors, application of, 345.
Floco, definition of, 440.
Flood, definition of, 441.
Flouring, definition of, 441.
Flow coat, definition of, 441; coating, definition of, 441; coating in motor car finishing, 398; of lacquers and formulation, 199; -out test of thinners, 223.
Flowing, definition of, 441.
Flowmeter, definition of, 441.
Fluid, definition of, 441.
Fluidity, definition of, 441.
Flushed colors, 111.
Flux, definition of, 441.
Foots, definition of, 441.
Force dry, definition of, 441.
Ford cup, definition of, 278, 441.
Formulas of finishes, 155, 199.
Formulation of finishes, hints on, 193.
Fossil gum resins, definition of, 55, 441.
Four hour enamels, development of, 6; finishes, definition of, 62, 441.
Foxy, definition of, 441.
Free flowing, definition of, 442.
French polish, definition of, 373, 442; walnut finish, bleaching agent for, 356.
Fresco colors, definition of, 442.

- Frosting, definition of, 442.
Full coat, definition of, 442; drying, definition of, 442.
Fuller's earth, definition of, 442.
Fullness, definition of, 442.
Furfural, 40.
Furfuryl alcohol, 41.
Furniture finishes, tests as applied to, 378; test values of, 381; finishing, 354.
Fusel oil, definition of, 441.
Fusible state, definition of, 442.
- Gallon**, definition of, 442.
Galvanized iron, definition of, 442.
Gamboe, definition of, 443.
Gang, definition of, 443.
Gardner-Holdt tubes, definition of, 278, 443; mobilometer, 279.
Gas black, definition of, 443; discoloration, definition of, 255, 304, 443; in pigmented lacquers, faults and corrections of, 304.
Gasoline discoloration of films, faults and corrections of, 304.
Gauge, Pfund film, for determining film thickness, 264.
Gelatinous, definition of, 444.
Gel, definition of, 443.
Gelling of bronzing lacquers, 164, 305.
Gel preventers in bronzing solutions, use of, 164.
Genealogy of lacquer and synthetic enamel coatings, 1.
Gilsonite, definition of, 56, 444.
Ginning of cotton, 12.
Glarimeter, definition of, 444; Ingersoll, 268.
Glass gilding, definition of, 444.
Glaze coat, definition of, 444.
Glazing, definition of, 444; knife, definition of, 444; putty, definition of, 444.
Gloss, definition of, 444.
Glossing up, definition of, 305, 444.
Glossmeter, definition of, 445.
Gloss of coatings, test for, 266; retention, definition of, 445.
Glutinous, definition of, 445.
- Glycerol phthalate or alkyd resins, 66; triacetate, 49.
Glyptal, definition of, 445.
Gold lacquer, definition of, 445; leaf, definition of, 445; rolls, definition of, 445; paint, definition of, 445; size, definition of, 445.
Goose flesh surface, 305, 445.
Gouging, definition of, 445.
Grain alcohol, definition of, 445; raising, definition of, 305, 316, 446; showing, definition of, 446.
Graining ink, definition of, 445; tools, definition of, 446.
Graphite, definition of, 446.
Gravity, definition of, 446; feed spraying, 323.
Gray in the pores, definition of, 305, 446.
Grayness after rubbing, definition of, 304, 446.
Grease resisting, definition of, 268, 446.
Greasy, definition of, 446.
Greening, definition of, 446.
Greenish cast, definition of, 446.
Green materials, definition of, 447; pigments, identification of, 93; inorganic, organic, 100, 102; toner, definition of, 447.
Grinding, definition of, 107, 447; equipment, 129; vehicle, definition of, 447.
Gritty, definition of, 447.
Ground coat, definition of, 447; color, definition of, 447.
Guide coat, definition of, 447.
Gum, definition of, 447; lacquer, 3; mastic, definition of, 447; rosin, definition of, 447; spirits of turpentine, definition of, 448; turpentine, definition of, 448; wood finishes, 369.
Gumming, definition of, 448.
Gun metal finish, definition of, 448.
Gypsum, definition of, 448.
- Hair lining**, definition of, 298, 305, 448.
Halpen method of determining rosin in lacquers, 228.

- Handling and storage of nitrocellulose and film scrap, 144.
- Hand method of dipping, 341; rubbing of wood finishes, 311.
- Hansa yellow pigment (organic), 102.
- Hanus number, definition of, 448.
- Hard gums, definition of, 448.
- Hardness, definition of, 256, 306, 448; meter, Pfund, 256; rocker, Sward, 258; tester, definition of, 449.
- Hard putty, definition of, 449; type synthetic resins for lacquers, 66.
- Hardwoods and their variety, 355.
- Hart impact tester, 242.
- Hats, finishes for, 171.
- Heartwood and figuration, 355.
- Heat and dipping, 342; convertible resin, definition of, 449; hardening, definition of, 449; resisting, definition of, 172, 449; test for nitrocellulose, 13; treating, definition of, 449; treatment of nitrocellulose solutions to reduce viscosity, 14.
- Heating as regards fire prevention, 148; oven, methods of, 162.
- Heaving, definition of, 306, 449.
- Heavy bodied, definition of, 449; oil, definition of, 449.
- Hellige comparator, 246.
- Hemp and the padding of paste wood filler, 361.
- Hercose AP, 23; C, 22.
- Herculoid nitrocellulose, 18.
- Hexabromide number, definition of, 449.
- Hexalin, definition of, 40, 450; acetate, 41.
- Hexyl acetate, secondary, 40.
- Hiding power, definition of, 307, 450; of finishes, test for, 252.
- High bake motor car pigmented primers, 389; boiling, definition of, 450; flash, definition of, 450; lighting, definition of, 450; oil absorption, definition of, 450; solids lacquer, definition of, 450; solvency thinner, definition of, 450.
- Hints, spraying, 334.
- Holidays, definition of, 307, 450.
- Hose, for spraying, 323.
- Hot lacquer, spraying of, 338.
- "H" scale and mother of pearl effect, 173.
- Hue as a distinguishable color quality, 86; definition of, 450.
- Huguenot walnut finish, bleaching agent for, 356.
- Humidity and blushing, 294; drying conditions, 269; chamber and the blush test number, 219; checks, faults and corrections, 298; control, 272; definition of, 269, 450.
- Hunter multipurpose reflectometer, 268.
- Hydrated chromium oxide pigments (inorganic), 101.
- Hydrocarbon, definition of, 450; test of thinners, 223.
- Hydrocarbons as a subdivision of diluents, 24.
- Hydrolysis test of solvents, 220.
- Hydrometer, definition of, 450.
- Hydroxide, definition of, 451.
- Hygrometer and relative humidity, 270; definition of, 451.
- Hygroscopicity of solvents, 28.
- Identifying** pigments, 93.
- Imitation marble finishes, requirements of, 173; mother-of-pearl finishes, 173; wood and marble grain on wood, 350.
- Impact resistance device, definition of, 451; test of finishes, 242; tester, Hart, 242; of the Bell Telephone Laboratories, 243.
- Imperial gallon, definition of, 451.
- Improper cleaning, definition of, 451; faults and corrections, 307; filler, faults and corrections, 303; ventilation, definition of, 451; ventilation, faults and corrections, 309.
- Indian red, definition of, 451.
- Inert, definition of, 451; pigments for lacquers, 105.
- Infra red lamps and the drying of synthetic enamel, 190.

- Infusible, definition of, 451.
Infusorial earth, definition of, 451.
Ingersoll glarimeter, 268.
Ingredient, definition of, 451.
Inhibitor, definition of, 451.
Initial color, definition of, 452.
Ink, definition of, 452.
Inlay, finishing of, 368.
Inorganic colors, definition of, 452.
Insoluble, definition of, 452.
Inspissate, definition of, 452.
Insulation, synthetic resins for, 75.
Insulating varnishes, definition of, 452.
Intensity, definition of, 452.
Interfacial tension, definition of, 452.
Interior finish, definition of, 452.
Iodine number, definition of, 452.
Iron black, definition of, 452; blue pigments (inorganic), 101; filler, definition of, 452; mill, definition of, 452; oxide, definition of, 452.
Isopropyl acetate, definition of, 452; value of, 34; alcohol, value of, 34.
Ivory black, definition of, 452.
- Jacobean** stain and period furniture finishes, 368.
Japan colors, definition of, 453; drier, definition of, 453; wax, definition of, 453.
Japanese lacquer, definition of, 453.
Jute tow and the padding of paste wood filler, 361.
- Kaolin**, definition of, 453.
Kauri butanol test for solvents, 221; definition of, 453; gum resin, 59; reduction test, definition of, 453.
Kerosene, definition of, 453.
Kettle bodied oil, definition of, 453.
Kicking up, definition of, 453; faults and corrections, 309.
Kieselguhr, definition of, 453.
Kiln drying, definition of, 453.
Kneading machine, 126.
Knit, definition of, 453.
- Laboratory** at the plant, 123; control procedure, 209; tests and analytical methods, 205.
Lac, definition of, 454.
Lacquer and early protective coatings, 1; varnish, compared with respect to drying, 366; as a synthetic, 7; definition of, 454; circulating system, 395, cleaners and removers, 187; coating, definition of, vi; colored, manufacture of, 117; colors, definition of, 454; composition of, 3; enamels, definition of, 454; finishing coats, motor car surfaces, 392; fires, how to combat, 141; ideal color for, 87; investigation of the name, 2; over old finishes, definition of, 454; other finishes, definition of, 309, 454; pigment chips, 110; production figures for the motor car industry, 385; spraying high solids, by the heating principle, 338; types of alkyd resins, 81.
Lacquers, tests applicable to, 227.
Lake, definition of, 454; Bordeaux, pigments (organic), 104; transparent yellow, pigments (organic), 102.
Lampblack, definition of, 96, 455.
Lap, definition of, 455.
Latent solvents, 24.
Latex, definition of, 455.
Laundryette, definition of, 455.
Leafing, definition of, 455.
Lean, definition of, 455.
Leather, finishes for, 174.
Length, definition of, 455.
Let down, definition of, 455.
Leveling out, definition of, 310, 455.
Liebermann-Storch method of determining rosin in lacquers, 228.
Life, definition of, 455.
Lifting, definition of, 310, 455; of lacquers or lacquer solvents, faults and corrections, 319.
Light fastness test (pigments), 90.
Lighting facilities in motor car finishing, 399.
Linolenin, definition of, 455.

- Linoleum lacquers**, requirements of, 175.
- Linseed oil**, definition of, 53, 455.
- Linters**, definition of, 456.
- Liquid**, definition of, 456; driers, definition of, 456; fillers, definition of, 456; mask, definition of, 456; stains and the staining of wood, 358.
- Litharge**, definition of, 456.
- Lithol red**, 104.
- Lithopone**, definition of, 456.
- Livering and bronzing lacquers**, 164; definition of, 311.
- Livery**, definition of, 456.
- Long**, definition of, 457; oil, definition of, 457.
- Loss of flexibility**, definition of, 311, 457.
- Lousiness**, definition of, 457.
- Low solvency thinner**, definition of, 457.
- Lubricant**, definition of, 457.
- Lustre**, definition of, 457.
- Machinery** as regards fire prevention, 147; finishes, definition of, 457.
- Madder lake**, definition of, 105, 457.
- Magnesium silicate**, definition of, 457.
- Mahogany finishes**, 369.
- Maintenance of standard samples**, 205.
- Maleic acid**, definition of, 457; anhydride, definition of, 457; formation of, 69.
- Manila gum resin**, definition of, 60, 457.
- Manjak resin**, definition of, 457.
- Mandrel test for finishes**, 240.
- Manufacture of alkyd resins**, 73; of phthalic anhydride, 67.
- Manufacturing equipment**, 124.
- Maple finishes**, 369.
- Marbling**, definition of, 458.
- Marbleizing**, definition of, 458.
- Maroon pigments (organic)**, 104.
- Masking tape**, definition of, 458.
- Mass tone in pigments**, test for, 87.
- Master standard**, definition of, 458.
- Mastic**, definition of, 458.
- Maximum temperature**, definition of, 458.
- Mechanical dipping**, 343; rubbing of wood finishes, 371.
- Medullary or pith rays and figuration**, 355.
- Melamine resins**, 84.
- Melting point**, definition of, 458; of resins, 225.
- Menhaden oil**, definition of, 458.
- Mercury vapor lamps in motor car finishing**, 394, 399.
- Metal dipping**, 342; finishes, clear, requirements of, 176.
- Metal finishes, colored**, requirements of, 176; primer, definition of, 458; signs and silk screen applications, 353.
- Metallic brown**, definition of, 458; soap, definition of, 458.
- Methanol**, definition of, 458.
- Method of matching thinners**, 458.
- Methods of oven heating**, 162.
- Methyl acetate**, definition of, 33, 458; alcohol, definition of, 33, 458; amyl acetate, definition of, 458; cellosolve, 37; ethyl carbinol, 35; hexalin, 41; propyl carbinol, 37; ethyl ketone, definition of, 459; isobutyl ketone, definition of, 459.
- Methylene chloride**, definition of, 459.
- Mica**, definition of, 459.
- Micron**, definition of, 459.
- Mildew**, definition of, 459.
- Milkiness**, definition of, 311, 459.
- Milking**, definition of, 459.
- Mill base**, definition of, 459.
- Mills**, grinding, 129.
- Milori blue**, definition of, 101, 459; green, definition of, 459.
- Mineral oil**, definition of, 459; spirits, definition of, 459; turpentine, definition of, 459.
- Minimum temperature**, definition of, 459.
- Miscibility**, definition of, 459; of thinners, test for, 211.

- Mist coat**, definition of, 459.
Mixers for manufacturing coatings, 124.
Mixing lacquers, definition of, 460.
Mobile, definition of, 460.
Mobility, definition of, 460.
Mobilometer, definition of, 279, 460.
Modern gums or resins, definition of, 55.
Modified alkyd resins, 73; phenol resins, 65; resins, definition of, 460.
Modifying agent, definition of, 460; agents of alkyd resins, 71.
Moisture, definition of, 311, 460.
Moisture content, definition of, 460; of wood, 355; of cellulose acetate, test for, 235; resistance of phenol resins, 64; troubles, definition of, 460.
Molding, synthetic resins for, 75.
Monkey, definition of, 460.
Monoethanolamine, definition of, 460.
Montan wax, definition of, 460.
Motor car finishes, accelerated pimpling test for, 255; and finishing, 385; finishing operations, 386.
Muddy, definition of, 460.
Mulling, definition of, 461.
Multiple pressure system of spray applications, 325.
Munsell universal photometer, 266.
Muriatic acid, definition of, 461.
Murky or muddy finishes, definition of, 311.
Mushy, definition of, 461.
- Naphtha**, definition of, 461.
Naphthyl blue, definition of, 461.
Natural resins, definition of, 461.
Naval stores, definition of, 461.
Neutrality, definition of, 461.
Neutral oil, definition of, 461; and hand rubbing of wood finishes, 371; toner, definition of, 461.
Nibs, definition of, 461.
Nigrometer, 254.
Nigrosine, definition of, 461.
Nitrate dope, definition of, 462.
Nitration of cotton, definition of, 12, 462.
- Nitrocellulose**, definition of, 10, 462; as regards fire prevention, 144; blending of, 195; for brushing lacquers, 339; storage at plant, 119.
Nitrocotton, definition of, 462.
Nitrogen content of cellulose nitrate, 10; oxide fumes in finishes, 304; peroxide in lacquer fires, 153.
Non-bleeding, definition of, 462; -drying, definition of, 462; non-drying oil, definition of, 462; gelling bronzing lacquers, requirements of, 164; grain raising stains and the staining of wood, 358; heat reactive phenol resins, 63; lifting solvents and formulation, 198; polar solvents, definition of, 462; shrinking, definition of, 462; spotting lacquers, definition of, 462; volatile, definition of, 462.
Normal butyl alcohol, 35.
Nozzle type water wash exhaust system spray booth, 328.
Nubs, definition of, 463.
- Ochre**, definition of, 463.
Octyl acetate, 42.
Odorless lacquer finishes, requirements of, 177.
Odor of solvents, 29; test for, 211.
Off color, definition of, 312, 463.
Oil, absorption, definition of, 91, 463; castor, 52; chinawood, 52; coconut, 52; colors, definition of, 462; cottonseed, 52; definition of, 463; in or with lacquer, faults and corrections, 312; length, definition of, 463; linseed, 53; modified phenol resins, 63; polish, definition of, 463; rapeseed, 53; resistance, definition of, 463; rubbing, definition of, 463; separator and spraying, 322; soluble, definition of, 463; stains and the staining of wood, 358; stains, definition of, 464; under lacquer, 464; undercoats and railway finishes, 180;

- vs. water rubbing of wood finishes, 372.
- Oils, tests applicable to, 224.
- Old age cracks, faults and corrections of, 299.
- Oleoresin, definition of, 464.
- One coat finish, definition of, 464; way drum, definition of, 464.
- Opacity, definition of, 464.
- Opal blue, definition of, 464.
- Opalescent lacquers, definition of, 464.
- Opaque, definition of, 464; maroon pigments (organic), 105.
- Operations of motor car finishing in 1927, 394.
- Orange mineral, definition of, 464; peel, definition of, 312, 464; shellac, definition of, 57, 464.
- Organic colors, 98.
- Outdoor exposure rack, 124; testing of coatings, 286.
- Oven baked, definition of, 464; heating, methods of, 162.
- Over baked, definition of, 313, 464.
- Overtone, definition of, 465.
- Oxalic acid and non-gelling bronzing lacquers, 164.
- Oxidation, definition of, 465.
- Oxidizing, definition of, 465.
- Ozokerite, definition of, 465.
- Padang** dammar, definition of, 465.
- Paint, definition of, 465; fan, definition of, 465; gauge, definition of, 465; meter, definition of, 465.
- Painting, definition of, 465.
- Paint mill, definition of, 465.
- Paint remover, definition of, 313, 465.
- Palladium leaf, definition of, 466.
- Panel exposure, definition of, 466.
- Paper, lacquers for, 177; marking, definition of, 466.
- Paracoumarone gum, definition of, 466.
- Paraffin oil, definition of, 466.
- Paraplex resins, 82.
- Para red, definition of, 103, 466.
- Parks dry-o-graph, 260; film-o-graph, 263.
- Particle size of pigments, 111.
- Passive, definition of, 466.
- Paste, definition of, 466; filler, definition of, 360, 466.
- Pasty, definition of, 466.
- Pearl essence, definition of, 466; finish, definition of, 466.
- Pebble mill, definition of, 133, 466.
- Pebbling, definition of, 466.
- Pebbly finish, definition of, 313, 467.
- Peeling, definition of, 313, 467.
- Penetrating stain, definition of, 467.
- Pentacetate, 38.
- Pentasol, 37.
- Perilla oil, definition of, 467.
- Period furniture finishes, 368.
- Perishing, definition of, 467.
- Permanence of color, definition of, 89, 314, 467.
- Permanency rating of some red pigments, 91.
- Petroleum, definition of, 467; hydrocarbons, 25, 43; spirits, definition of, 467.
- Pfund cryptometer, 253; film gauge, 264; hardness meter, 256; multiple reflection colorimeter, 246.
- Phenac resins, 65.
- Phenol aldehyde resins, definition of, 467; formaldehyde resins, 62; resins, definition of, 62.
- Phenolic resins, definition of, 467.
- Philippine mahogany, finishing of, 369.
- Photometer, Munsell Universal, 266.
- Phthalic anhydride, definition of, 467; manufacture of, 67.
- Physical properties of solvents and non solvents, 32.
- Picking up, definition of, 314, 467.
- Pick marked, definition of, 468.
- Pigmentation, definition of, 468.
- Pigment compatible, definition of, 468; definition of, 85, 468.

- Pigments and formulation, 198; CP, description of, 89; dispersion of, 107; fading of, 90; grinding of, 107; milling of, 88; non-bleeding, 100; oil absorption of, 91; permanency rating of, 89; refractive index of, 90.
- Pigment stains, definition of, 468.
- Piling, definition of, 314, 468.
- Pine oil, definition of, 43, 468.
- Pinholding, definition of, 314, 468.
- Pitch, definition of, 469.
- Pith or medullary rays and figuration, 357.
- Pitting, definition of, 315, 469.
- Planetary crack type spray coating machine, 337.
- Plant and equipment for manufacturing coatings, 113.
- Plaster of paris, definition of, 469; molds, finishing of, 167.
- Plasticiser, definition of, 46, 469; cracks, faults and corrections of, 299; and formulation, 198; for brushing lacquers, 340; cellulose acetate, 53; volatility of, 47.
- Plasticity, definition of, 470.
- Plastic resin, definition of, 469; type synthetic resins for lacquers, 66.
- Pliable, definition of, 470.
- Pock marking, definition of, 315, 470.
- Polariscope, definition of, 471.
- Polarized phenol resins, 64.
- Polar solvents, definition of, 471.
- Polishes, definition of, 471.
- Polishing, definition of, 471; mediums, 373; of wood finishes, 371; wheels in motor car finishing, 394.
- Polychrome, definition of, 471.
- Polyhydric alcohols, 71.
- Polymerization, definition of, 471.
- Polystyrene resins, 84.
- Pontianak, definition of, 60, 471.
- Poppyseed oil, definition of, 471.
- Pores of wood, 355.
- Porous, definition of, 471.
- Portable sander, use of, 365.
- Potassium ferrocyanide, definition of, 471.
- Pounding, definition of, 471.
- Powdering, definition of, 471.
- Powder stains, definition of, 472; and the staining of wood, 357.
- Precipitate, definition of, 472.
- Preparation of motor car surfaces for lacquering, 386; veneer panels for tests, 379.
- Pressing, definition of, 472.
- Pressure feed, definition of, 324, 472.
- Prewetting of pigments before dispersion, 109.
- Primary colors, definition of, 86, 472.
- Prime coat, definition of, 472.
- Primer and refrigerator finishing, 183; definition of, 472; for motor car surfaces, 389; of the phenol type, air drying, 63.
- Printing, definition of, 315, 472; of films, test for, 260, 262.
- Production figures of lacquer in the motor car industry, 385.
- Proof spirit, definition of, 473.
- Properties of paste wood fillers, 362; of present day synthetic enamels, 191; of some plasticisers, 49.
- Propylene oxide, definition of, 473.
- Prussian blue, definition of, 101, 473.
- Prussiate of potash, definition of, 474.
- Psychrometer and relative humidity, 270.
- Puckering, definition of, 315, 474.
- Pudding, definition of, 474.
- Pulling out, definition of, 474; under the brush, 474.
- Pulverulent, definition of, 474.
- Pumice stone, definition of, 373, 474.
- Purification after nitration, 13; of cotton, 12.
- Putty coat, definition of, 179, 474; knife, definition of, 474.
- Pyridine in alcohol, test for, 218.
- Pyroxylin, 3.

- Qualitative test for nitrocellulose solutions**, 227.
- Queen Anne finish**, 368.
- Quick drying paste wood fillers**, 361; touch-up and refinish of motor car surfaces, 399.
- Railway finishes, requirements of**, 180.
- Rain spotting, definition of**, 475.
- Raising of the grain, definition of**, 316, 475.
- Raisin seed oil, definition of**, 475.
- Rapeseed oil**, 53.
- Rating in the evaluation of wood finishes**, 383.
- Rat tailing, definition of**, 475.
- Raw materials for alkyd resins**, 67; **sienna**, definition of, 475; **umber**, definition of, 475.
- Reagglomeration of pigments**, 111.
- Reclamation of sprayed materials**, 383.
- Recoalescence, definition of**, 475.
- Red, cadmium, pigments (inorganic)**, 102; **lead**, definition of, 475; **lithol, pigments (organic colors)**, 104; **oxide**, definition of, 475; **para, pigments (organic)**, 103; **pigments, identification of**, 93; **permanency rating of**, 91; **settling of**, 107; **toluidine, pigments (organic)**, 103; **toner**, definition of, 475.
- Reduced colors**, 98.
- Reduce, definition of**, 475.
- Reducer, definition of**, 476.
- Reduction of lacquer**, 316; **paste wood fillers**, 362.
- Refined dry bleached shellac**, 57.
- Refinishing motor car surfaces**, 398.
- Refinish without surfacing motor cars**, 399.
- Reflectometer, hunter multipurpose**, 268.
- Refractive index and the permanency of pigments**, 90; **definition of**, 476.
- Refractometer, definition of**, 476.
- Refrigeration and the weather-o-meter**, 285.
- Refrigerator finishes, requirements of**, 181.
- Reinforcing agent, definition of**, 476.
- Relative humidity and blushing**, 295; **its influences on wood**, 356; **definition of**, 269, 316, 476.
- Removers, requirements of**, 187.
- Requirements of finishes**, 155.
- Residuals in lacquer solutions, test for**, 232.
- Resinate, definition of**, 476.
- Resin, definition of**, 55, 476; **hardness**, definition of, 476; **formulation, alkyd**, 72; **manufacture, alkyd**, 73; **for brushing lacquers**, 340; **solvents**, 25; **storage at the plant**, 119; **tests applicable to**, 225.
- Resinify, definition of**, 477.
- Resurface and refinishing of motor cars**, 398.
- Retarders, definition of**, 295, 476.
- Rezyls, definition of**, 82, 476.
- Rhe, definition of**, 476.
- Rhoduline heliotrope, definition of**, 476.
- Ribs, definition of**, 476.
- Rigidity, definition of**, 476.
- Roller coating, definition of**, 179, 348, 477; **mill, definition of**, 129, 477.
- Ropey, definition of**, 477.
- Rosazeine, definition of**, 477.
- Rosin, definition of**, 477; **ester, definition of**, 477; **modified phenol resins**, 62; **oil, definition of**, 477; **test of nitrocellulose solutions**, 228.
- Rotary spray finishing machine**, 337.
- Rottenstone, definition of**, 373, 477.
- Rough stuff, definition of**, 477.
- RS nitrocellulose**, 15.
- Rubber finish, definition of**, 478.
- Rubbing, definition of**, 478; **block, definition of**, 478; **brick, definition of**, 478; **compound, definition of**, 478; **faults and corrections**, 317; **felt, definition of**, 372, 478; **of wood fin-**

- ishes, 371; oil, definition of, 373, 478;
stone, definition of, 478; through,
definition of, 316, 478.
Runs, definition of, 479.
Rusting, definition of, 479.
- Sags**, definition of, 479.
Salol, definition of, 479.
Salt spray testing device, definition of,
272, 479.
Sandarac, definition of, 60, 479.
Sandblasted finishes, 373.
Sandblasting of metal surfaces, 308.
Sanding between coats, 317; in the
white, definition of, 317, 365, 479;
sealer as a finishing lacquer, 364;
definition of, 363, 479; surfacer, def-
inition of, 479.
Sandometer, definition of, 261, 479.
Sandpaper and sanding, 364; definition
of, 479.
Sandy, definition of, 480.
Santicizer, definition of, 480.
Saponification number, definition of,
480; of oils, test for, 225; solvents,
test for, 211.
Sardine oil, definition of, 480.
Satin finish, definition of, 480.
Saturated air and blushing, 294; dry-
ing conditions, 269.
Scaling, definition of, 317, 480.
Scarlet lake, definition of, 481.
Schedule, definition of, 481.
Scraper, definition of, 481.
Scratches, definition of, 481.
Scratch tester, 259.
Screen test, definition of, 481.
Sealer, definition of, 481.
Sebacic acid, definition of, 481.
Secondary amyl acetate, 38; butyl ace-
tate, 36; butyl alcohol, 35; hexyl
acetate, 40.
Seediness, definition of, 317, 481.
Semi drying oils, definition of, 481;
flat lacquer, definition of, 482; gloss,
definition of, 482; transparent, def-
inition of, 482.
- Separation, definition of, 317, 482.
Setting up, definition of, 482.
Shade and strength test of pigments,
87; definition of, 482.
Shading lacquers, 365.
Sharp dryer, definition of, 482; lustre,
definition of, 482.
Sheary, definition of, 482.
Sheen, definition of, 482.
Shellac, 56, 482; and alcohol soluble
nitrocellulose, 58; cutting tanks, 126;
in the finishing industry, uses of, 58;
sealer coat, 309; substitute, definition
of, 483; under lacquer, use of, 377;
varnish, definition of, 483.
Shine, definition of, 483.
Short, definition of, 483.
Shortness, definition of, 483.
Shrinkage, definition of, 318, 483.
Sienna, definition of, 485.
Silex, definition of, 485.
Silica, definition of, 485.
Silicate of soda, definition of, 485.
Silking, definition of, 485.
Silk screen stencil lacquers, definition
of, 188, 485; application of, 351.
Silt, definition of, 485.
Silver lacquer nitrocellulose, 17; leaf,
definition of, 485.
Singapore dammer, definition of,
485.
Sinking in, definition of, 318, 485.
Size, definition of, 485.
Skinning, definition of, 318, 486.
Skin troubles, definition of, 486.
Skips, definition of, 486.
Slippery, definition of, 486.
Slow evaporating, definition of, 486.
Slush, definition of, 486.
Smalt, definition of, 486.
Smokeless powder and cellulose ni-
trate, 4.
Smoky, definition of, 486.
Soaking or swelling of colloidal pig-
ment chips, 110.
Sodium bisulphite as a bleaching agent,
356.

- Soft, definition of, 486; woods and their variety, 355.
- Softeners, definition of, 486.
- Softness, definition of, 486.
- Solid, definition of, 487; covering, definition of, 487.
- Solids of sanding sealers, 364; total, in lacquers, test for, 228.
- Soligen driers, definition of, 487.
- Solubility, definition of, 487; of cellulose compounds, 22.
- Solution, definition of, 487.
- Solvency, definition of, 487.
- Solvent, definition of, 487; extraction, examination of, 233; naphtha, definition of, 487; power of liquids, 27; pumping system for, 117; storage at the plant, 118; tolerance, definition of, 487.
- Solvents and non solvents in order of their boiling points, 24, 30; as regards fire protection, 146; classification of, 25; for AS gum resins, 198; brushing lacquers, 339; cellulose acetate, 44; use with alkyd resins, 80; tests applicable to, 211.
- Sorts, definition of, 487.
- Soybean oil, definition of, 487.
- Spatter lacquers, requirements of, 188.
- Spatula, definition of, 487.
- Specially denatured alcohol, 32; and viscosity, 276.
- Specific gravity, definition of, 488; conversion chart, 215; method of determining, of solvents, 213; and viscosity, 276.
- Spectrometric equipment, 248.
- Spectrophotometer, definition of, 488.
- Spider legs, definition of, 488.
- Spinning, film, device, and hiding power, 252.
- Spirit soluble stains and the staining of wood, 358; stains, definition of, 488; varnishes, definition of, 488.
- Spirits of turpentine, 488.
- Split, definition of, 488.
- Sponges, definition of, 488.
- Spot dry time, definition of, 489; glaze application in motor car finishing, 391.
- Spotting, definition of, 489.
- Spotty drying, definition of, 318, 489.
- Sprayability, test for, 211.
- Sprayed material, reclamation of, 383.
- Spray booth, location of, 327; water wash, 325; gun, definition of, 489; touch up, 334; troubles, definition of, 318, 489.
- Spraying, application by, 321; definition of, 489; directly from the drum, 376; faults, 333; high solids lacquer by the heating principle, 338; hints, 334; method, applications by the 334; of paste wood filler, 362; rotary, finishing machine, 337.
- Spreading rate, definition of, 489.
- Squeegee coat, definition of, 489; dipping, 344.
- SS nitrocellulose, 18.
- Stabilisol "A" and non gelling bronzing lacquers, 164.
- Stability of solvents, 26.
- Stain bleeding, definition of, 489; types of, in wood finishing, 357.
- Staining of wood and the use of stains, 357.
- Standard, definition of, 489.
- Stand oil, definition of, 489.
- Static electricity as regards fire prevention, 148.
- Steam distillation, definition of, 490; distilled wood turpentine, 490; in combating lacquer fires, 151.
- Steel blue pigments, 101; wool, definition of, 490.
- Stick shellac, definition of, 490.
- Stiff, definition of, 490.
- Stiffness, definition of, 490.
- Stimulator, definition of, 490.
- Stippled finish, definition of, 490.
- Stipple lacquer, definition of, 188, 490.
- Stock, definition of, 490.
- Stone mill, definition of, 133, 491.

- Stop off enamel, definition of, 491.
Stormer viscosimeter, 277.
Straight phenol resins, heat reactive, 63; permanently fusible, 63.
Streaked finish, definition of, 319, 491.
Street car finishing, 397.
Strength, definition of, 491.
Stress strain of films, 274.
Strike, definition of, 491.
Striking in, definition of, 319, 491.
String, definition of, 491.
Styrene, definition of, 491.
Succinic acid, definition of, 491; acid, formation of, 70.
Suction, definition of, 491; feed, spraying by, 323.
Sulfonated castor oil, 52.
Sulphuric acid solubility of solvents, test for, 212; ether, 32.
Sulphur test of thinners, 224.
Sundays, definition of, 491.
Sunflower seed oil, definition of, 491.
Surfacers in motor car finishing, 389; of the phenol type, air drying, 63.
Surface, definition of, 491; drying, definition of, 491; gilding, definition of, 491; tension, definition of, 492.
Surfacer, definition of, 491.
Sward hardness rocker, 258.
Sweating, definition of, 319, 492.
Swelling solvent, definition of, 319, 492.
Syneresis, definition of, 492.
Synthetic, definition of, 492; enamels and aircraft finishes, 160; an abrasion test, 236; coating, definition of, vi; and dipping, 170; finish, selection of resin for, 189; flow coating, 398; grease resistance test, 268; heat resisting, 173; motor car finishes, 398; properties of, 191; refrigerator finishing, 187; roller coating, 179; in bus, truck and street car finishing, 398; primer and refrigerator finishing, 183; resins, 60; and clear metal finishes, 176; and motor car finishes, 386; silk screen stencil pastes, 188; definition of, 55, 492; for bonding, insulating and molding, 75; lacquers, 66; in baking enamel finishes, 78; house paints, 78; pigmented auto body lacquers, 76; rubbing varnishes, 76; solvents, development of, 6.
- Tack free, definition of, 493.
Tackiness, definition of, 319, 493.
Tackragging of motor car bodies, 392.
Talc, definition of, 493.
Tank for the manufacture of thinner, 118; for dipping, 342.
Tarnish, definition of, 493.
Tears, definition of, 493.
Teglac, definition of, 83, 493.
Temperature and humidity control, 270; change of finishes, test for, 245; test and film ruptures, 383; checking, definition of, 493.
Tensile strength and elongation apparatus, 274; definition of, 493.
Tension, definition of, 493.
Terra alba, definition of, 493.
Tertiary amyl alcohol, 35.
Tested materials, definition of, 493.
Test for abrasion of finishes, 236, 239; accelerated pimpling of finishes, 255; acetyl content of cellulose acetate, 235; acidity of solvents, 212; acid number of oils, 224; adhesion of finishes, 239; of wood lacquer finishes, 239; alcohol print test of finishes, 239, 244; resistance of finishes, 243; baking of finishes, 244; baumé, 214; bending of finishes, 195; benzol dilution of thinners, 222; bleeding of pigments, 93; blushing of solvents, 219; thinners, 244; bubbling (viscosity), 415; cellulose acetate (moisture), 234; cold checking of finishes, 245; color of solutions, 245; criss cross ruptures, 241; dilution ratio of cellulose acetate, 215; solvents, 215; diphenylamine—nitrocellulose solutions, 227; discoloration

- of films, 255; distillation of thinners, 212; drying of finishes, 260; dryness of solvents, 212; ester—thinners, 223; evaporation rate of solvents, 219; exposure of films, 286; extraction of residuals, 232; film discoloration of finishes, 255; thickness, 263; flexibility of finishes, 239; flow out of thinners, 223; furniture finishes, 378; gas discoloration of finishes, 255; gloss of finishes, 266; grease resistance of finishes, 268; hardness of finishes, 256; heating of nitrocellulose, 13; hiding power, 252; humidity, 272; hydrocarbons in thinners, 223; hydrolysis of solvents, 220; impact resistance of finishes, 242; lacquers, 227; light fastness of pigments, 90; mass tone—pigments, 87; miscibility of finishes, 211; moisture of cellulose acetate, 235; odor of finishes, 211; oils, 224; permanency of red pigments, 91; printing of finishes, 262; pyridine in alcohol, 218; residuals in finishes, 232; resins, 225; rosin in nitrocellulose solutions, 228; salt spray resistance of finishes, 272; saponification—oils, 225; solvents, 211; scratch resistance of finishes, 259; specific gravity—thinners, 213; sprayability of finishes, 211; sulphuric acid solubility of solvents, 212; sulphur in thinners, 224; temperature, 383; changes of finishes, 245; tensile strength of finishes, 274; tolerance of solvents, 218; toluol dilution factor—thinners, 222; total solids of solutions, 228; toughness of finishes, 239; vapor pressure of solvents, 221; viscosity of finishes, 275; water solubility of solvents, 212; weathering of finishes, 281; weight per gallon, 231; panels, definition of, 493; racks, 493.
- Tests as applied to furniture finishes, 378; values of finishing investigations, 381.
- Testing pigments for shade and strength, 87.
- Tetralin, definition of, 42.
- Thermoplasticity, definition of, 493.
- Thermoplastic nature of alkyd resins, 79.
- Thermometer, definition of, 494.
- Three roller mill, 130.
- Thick, definition of, 494.
- Thicken, definition of, 494.
- Thickness of film, definition of, 263, 494.
- Thinner, definition of, 222, 320, 494.
- Three quarter gloss, definition of, 494.
- Thumbnail proof, definition of, 494.
- Tiffany finish, definition of, 494.
- Tint, definition of, 494.
- Tinting colors, definition of, 494; strength, definition of, 494.
- Tintometer, definition of, 495.
- Titanated lithopone, 495.
- Titanium dioxide, definition of, 95, 495; pigments, definition of, 495.
- Tits, definition of, 495.
- Tolerance, definition of, 28, 218, 495.
- Toluidine red, definition of, 103, 495.
- Toluol, definition of, 43, 495; dilution factor of thinners, test for, 222; precipitation method for lacquers, 230.
- Toners, definition of, 496.
- Toning a finish by use of shading materials, 365.
- Tornesit, 23.
- Torsion type viscosimeter, 278.
- Total solids in lacquers, qualitative test for, 228.
- Touch up spray gun, 334.
- Toughness, definition of, 293, 496.
- Toxicity, definition of, 29, 496.
- Toy and novelty finishes, 496.
- Traffic lacquers, requirements of, 191.
- Transparent yellow lake pigments (organic), 102.
- Triacetin, definition of, 49, 496.
- Triangular coordinate charts and formulation, 197.
- Tributyl phosphate, 51.

- Triethanolamine, definition of, 496.
Tricresyl phosphate, definition of, 50, 496.
Triglyceride of ricinoleic acid, 52.
Triphenyl phosphate, definition of, 51.
Truck finishing, 397.
True solvents, 24.
Tube body, definition of, 496.
Tubes, Gardner-Holdt, 278.
Tumble finish, definition of, 496.
Tumbling barrels in coatings, use of, 192; definition of, 496; finishes, requirements of, 192; method of finishing, 347.
Tung oil, definition of, 496.
Turbidity, definition of, 496.
Turpentine, definition of, 43, 496; substitute, definition of, 496.
Tuscan red, definition of, 497.
Types of finishes, 155; nitrocellulose, 14; stain used in wood finishing, 357.
- Ultramarine** blue, definition of, 497; pigments, 105.
Ultramicroscope, 111.
Ultraviolet light, definition of, 497; resistant, definition of, 497.
Umber, definition of, 497.
Underbaked, definition of, 497.
Undercoat or sanding sealer, 363; troubles, definition of, 497.
Undercoater cracks, faults and corrections, 299.
Undercoats, definition of, 497; in motor car finishing, 389.
Undertone, definition of, 497.
Undried filler, faults and corrections, 304.
Unmodified compounds of polybasic acid and polyhydric alcohols, 74.
Unsaponifiable matter, definition of, 497.
Unseasoned, definition of, 497.
Urea-Formaldehyde resins, definition of, 83, 497.
Uviarc and film discoloration, 255.
- Vacations**, definition of, 497.
Value, as a distinguishable quality of color, 86.
Vandyke brown, definition of, 497.
Vapor pressure of solvents, test for, 221.
Vaporize, definition of, 497.
Variety of hard and soft woods, 355.
Varnish and lacquer, compared with respect to drying, 366; definition of, 498.
Vegetable oils, definition of, 499.
Vehicle, definition of, 499.
Veiling lacquers, requirements of, 192.
Veneer, definition of, 499; panels, preparation of, for tests, 379; surface finishes, 369.
Venetian red, definition of, 499.
Ventilation, improper, faults and corrections of, 309; within an oven, 163.
Venting and ventilating as regards fire prevention, 148.
Vinylite, definition of, 83, 499.
Viscometer, electro-, 280.
Viscosimeter, definition of, 499; stormer, 277; torsion type, 278.
Viscosity and specific gravity, 276; definition of, 500; falling ball method, 276; determination by the Ford cup method, 278; for nitrocellulose, 14; of coatings, test for, 275; tubes, Gardner-Holt, 278.
Volatile thinner, definition of, 500; vehicle, definition of, 500.
Volatility of plasticisers, 47.
- Walnut** finishes, 370.
Warping, definition of, 500.
Wash coat, definition of, 500.
Water colors, definition of, 500; dip lacquers, 3; glass, definition of, 500; in alcohol, faults and corrections, 289; or with lacquers, faults and corrections, 312; separator and spraying, 322; soluble stains and wood finishing, 357; solubility of solvents, test for, 212; spotting, definition of, 500; stains, definition of, 500; vs. oil

- rubbing of wood finishes, 372; wash exhaust system, spray booth, 328, 330; spray booths, 327; white, definition of, 500.
- Waxes, definition of, 500.
- Weak colors, definition of, 501.
- Weatherometer, definition of, 283, 501.
- Weather resisting, definition of, 501; tests, accelerated, 281.
- Weight, definition of, 501; per gallon of solutions, test for, 231.
- Well type cryptometer, 253.
- Wet bulb thermometer and relative humidity, 270.
- Whirling, coating by, 346; lacquer finishes, 192; machine, definition of, 501.
- White lead, definition of, 501; settling of, 106.
- Whitening, definition of, 501.
- White pigments, 94; settling of, 106; shellac, definition of, 57, 501.
- Whitening, definition of, 501.
- Wind break, definition of, 501.
- Wood alcohol, definition of, 33, 501; and its structure, 355; and its variables, 354; as a chemical product of cellulose, 11; cells or fibres, 355; contraction and expansion of, 354; dipping of, 341; filler, definition of, 360, 502; flour, definition of, 502; lacquers, clear and flat, 366; oil, definition of, 502; rosin, definition of, 502; staining of, 357.
- Workability, definition of, 502.
- Working test of finishes, laboratory, 211.
- Wrinkle finish, definition of, 502.
- Wrinkling, definition of, 502.
- Xylol, definition of, 502; non-solvent values, 43.
- Yacca gum, definition of, 502.
- Yellow, Hansa, pigment (organic), 102; lakes, transparent pigments (organic), 102; pigments, identification of, 93; (inorganic colors) and organic colors, 99, 102; settling of, 106.
- Yellowing, definition of, 502.
- Yield point, definition of, 502; value, definition of, 502.
- Zanzibar, definition of, 503.
- Zinc caskets, finishing of, 166; chromate synthetic primer, 397; oxide, definition of, 503; palmitate, 105; pigments, manufacture of, 94; stearate, 105; sulphide, definition of, 503; white, definition of, 503; yellow pigments (inorganic), 99.

